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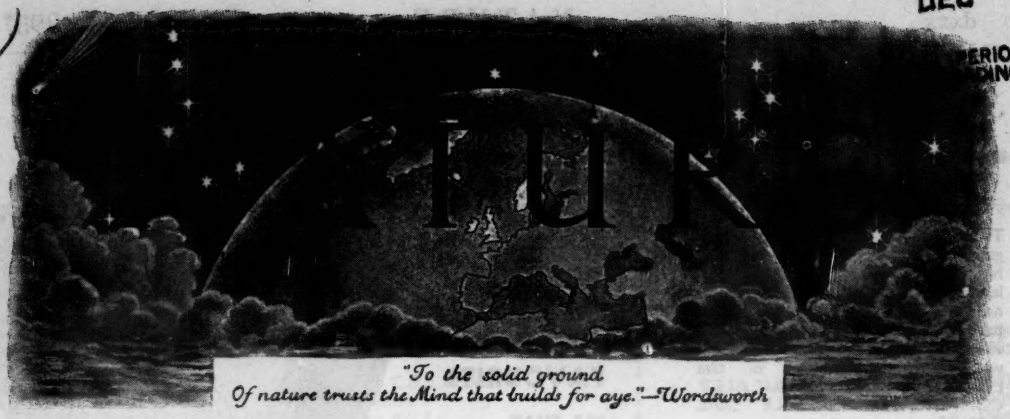

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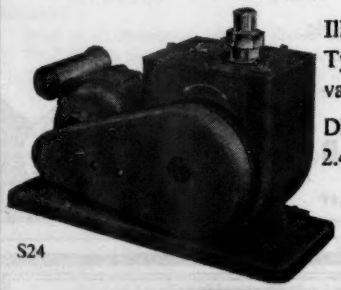

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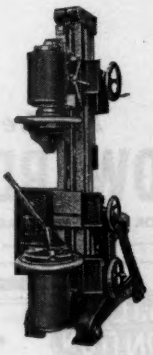

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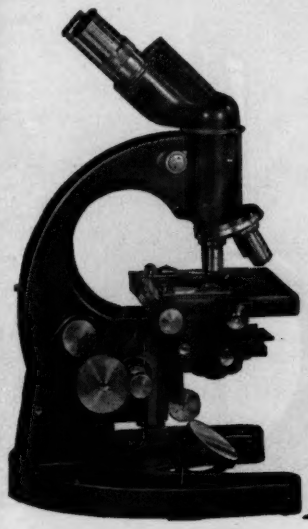

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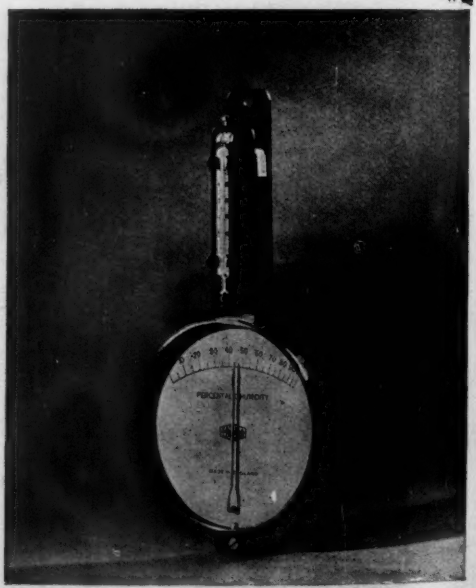

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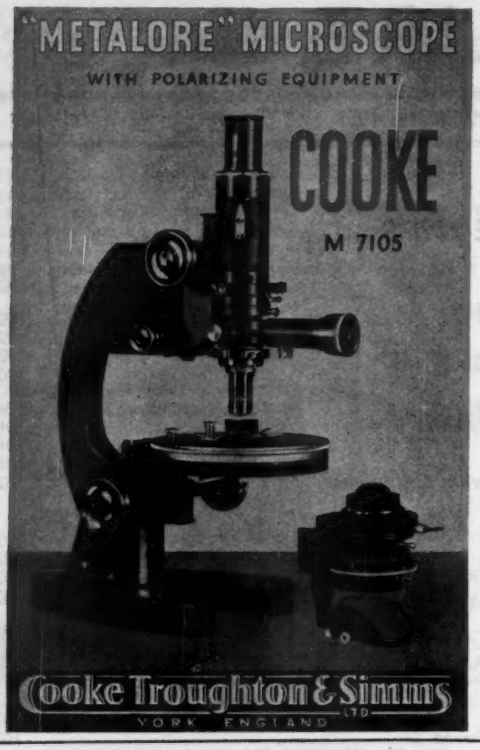

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CORPORATE LIFE IN UNIVERSITY EDUCATION

ALMOST from its establishment, the University Grants Committee has emphasized the importance of corporate life as an essential part of university education, returning to this thesis in almost every report since 1921. In 1942 strong support was forthcoming from the British Association Committee on Post-War University Education, which recommended that at least one year of residence in college or in a university hostel should be required of every internal candidate for a first degree, and a further report from the same Committee ten months later noted a general call for better residential facilities at the modern universities. The Association of University Teachers, in its report on University Developments published in 1944, also advocated the one-year residential principle as an immediate objective, with a full residential system of university education as the ultimate objective. Since 1945, moreover, when it was enabled to give capital grants to universities, the University Grants Committee has placed at the disposal of the universities funds for providing halls of residence, as well as playing fields, students' unions and refectories, without which a fuller corporate and social life becomes well-nigh impossible.

Changes since the War have accentuated the need for increasing the provision of student facilities and amenities in Britain quite out of proportion to the increase in numbers of students. The increase in numbers has in itself made it all the more difficult to find satisfactory lodgings for those students who cannot gain admission to a hall of residence and whose homes are too distant from the university for daily travel to be practicable. Again, with the steadily increasing proportion of students who are in receipt of some form of assistance from public funds, there is a growing number drawn from homes where the accommodation is too limited or the tradition of learning too slender for the student to enjoy the conditions he or she needs for effective and strenuous study.

The very dependence of such students upon State scholarships and other public awards, and the competition to gain admission to a university, point to cases of failure in a way that did not formerly arise; but attention is being focused upon the expansion of halls of residence not simply because lodgings and home life have often failed to provide satisfactory conditions, but because of the positive contribution which living in a hostel or hall of residence usually makes to the development of a student. The expanding frontiers of knowledge, the growing content of curricula, and the increasing specialization of courses both in arts and science tend to leave most students too little time or inclination for the development of those wider interests which should be part of their heritage at a university. Both in regard to the expansion of higher technological education and of university education in general, the importance of an adequate broad general education has been freely emphasized, and while there may be wide differences of opinion as to the content of such a general education or where it can best be given, it is widely accepted that an essential part of it is received from contact with fellow students.

In a recent survey of graduates in industry, Political and Economic Planning noted that, in the suggestions made by members of management as to ways in which the universities could do more to meet the needs of industry, stress was laid on the provision of more halls of residence and the bearing of facilities for residence on the development of personality. The building programme for 1957–59 of the universities of Britain in fact includes halls of residence at thirteen universities and university colleges; and the universities are already giving a good deal of attention to the whole question of the bearing of extra-curricular activities on the general development of their students, although most of the modern universities of England and Wales were originally intended for local students and interest in residence has developed differently for each place. Whereas in the younger universities such as Reading, Southampton and Exeter, residence has been regarded as the natural and usual condition of a student's life, in the older civic universities, in large industrial cities, the idea of halls of residence developed empirically and as accretions when students from outside the local population were attracted and found that lodgings were squalid, dear or unobtainable. Again, in Scotland, by the end of the nineteenth century, the original residential system had long been forgotten and a tradition established by which students, if they could not live at home, lived cheaply in lodgings.

It was against this background that the University Grants Committee appointed a Sub-Committee on Halls of Residence, with Prof. W. R. Niblett as chairman, and its report has just been issued*. The report does not encroach on the field covered by the 1948 report on "The Planning of University Halls of Residence", simply urging that the building be designed for the maximum of privacy and quiet, and is perhaps content to dismiss the question of cost rather too completely. As Sir Keith Murray, chairman of the University Grants Committee, remarks in his foreword to the report, at about £1,500–£2,000 a student-place, the cost of such halls of residence appears high, and if substantial sums of public money are to be invested in their provision, a clear view is needed of their objective and of the conditions which determine their success or failure. The Sub-Committee was appointed to make such a fuller study of the educational role of the hall of residence, but the contrast between the figure just quoted and that of

* University Grants Committee. Report of the Sub-committee on Halls of Residence. Pp. vi+54. (London: H.M. Stationery Office, 1957.) 3s. net.

£800 for which, according to the Ministry of Education's Bulletin No. 15, places are provided at training colleges for teachers, and the £100 or so for each student place per annum, including capital and maintenance at 1938–39 prices, of the British Association committee is too startling to be passed over without searching inquiry as to the possibility of providing the essentials at something nearer the lower figures.

Having made this comment, it must be said that Prof. Niblett and his Committee have produced an admirable report. The problem is set fairly and clearly against both its historical background and the growing needs of to-day. The functions of the hall of residence are well defined as well as its practical limitations, and aims are conceived with vision as well as realism and in fairness to the main alternatives described to the Committee; while the conditions for success are indicated, there are also practical suggestions offering important opportunities for experiment. Appointed "To consider and report on the nature and importance of the role which should be played by halls of residence in the education of university students, and its relation to other forms of student organization; the manner in which halls of residence should be administered and staffed in order to carry out this role; and the arrangements within universities for formulating policy on these matters and for supervising its execution", the Niblett Committee has made a noteworthy contribution not merely to university policy in this field but also to thought on general education.

While the higher education of intellectually able young men and women, the promotion of learning and research, and the advancement of knowledge, are to-day accepted as three of the most important activities in a civilized community, the responsibility of the university for the liberal education of the student is not everywhere taken seriously enough. The Committee believes that he should mix with his fellows and seniors under conditions which encourage him to appreciate and discuss matters of the spirit and of the intellect at the highest level of which he is capable. The educated man must have come to some real degree of knowledge and begun to work out a philosophy of life, and in the Committee's opinion the hall of residence has a role of great importance in this wider education. Nevertheless, it does not imply that halls can, or should, take from the departments their share of the responsibility for developing close relations between staff and students. Nor does it suggest either that its conclusions will be easy to translate into practice or that there is any universally applicable 'blueprint' for halls of residence.

Despite the growing support for university residence, the proportion of university students in Britain living in halls of residence and colleges has increased too slowly during the past two decades; in 1955–56 only 27·5 per cent of the total of 85,194 university students were in residence, compared with about 24 per cent in 1934–35 out of the pre-War population of 50,090. Merely to maintain the present proportion would require a further 10,000 places during the next decade if the anticipated increase in student population materializes, even if the potential bulge in 1964–67 is disregarded. Moreover, apart from the impossibility of ignoring, in any planned expansion, the question of where the students are to live, there is on every side a demand for graduates who possess, as well as their specialized knowledge, a wide range of interests, initiative, consideration for others, a strong sense of personal integrity and a willingness to take responsibility. To succeed in the fullest sense, a university education must help the student to achieve these qualities. He can scarcely do so without living in comfortable conditions outside lecture hours, or as a member of a social group inspiring loyalty or providing personal contacts which will extend his interests.

The Niblett Committee is convinced of the great educational possibilities of a good hall of residence. It can provide the student with a society to which he really belongs. In it he has the stimulus of free and informal discussion with a wide variety of his contemporaries and the experience of living with others; the friendships he makes and his daily contacts with people from very different backgrounds all extend his social experience without divorcing it from his intellectual life, while the academic influences which surround the resident have time to sink in and become effective.

For all this to be possible, the hall must contain sufficient people able and willing to nourish it intellectually. The prime stress is laid upon the personality and character of the warden; but the support of a senior common room and the leavening of the student body by some exceptionally able members, preferably drawn from a variety of faculties, in each year of the course, are almost equally important factors. Physical conditions too are, of course, significant: it is probably an advantage to the residential student that he sees his seniors at work and insensibly gathers much from them about the best pace and method in study; but the successful halls are those which continually suggest new interests and points of view to their students. The Committee commends, for example, the institution of regular guest nights, when students have the opportunity of meeting interesting and distinguished people—members of their own or other universities, representatives of industry and the professions, or foreign visitors. It also stresses the importance of some element of dignity in the standards of living, such as maintenance of the older social traditions at formal dinners or on guest nights, and it refers to the student's obligations in a hall as well as his rights, and to the way in which he comes to realize that if he withholds his contribution, he diminishes the whole.

As regards practical recommendations and conclusions, the Niblett Committee agrees with the principle frequently expressed to it that the best size for the individual hall is probably 130–150 students, and where experiments are made in grouping halls on neighbouring sites with a number of services in

common, each hall should have its own warden and senior common room. On educational grounds, it believes that two years residence in the hall is desirable for most students admitted to membership, with an arrangement, whenever possible, for membership of the hall to be retained by ex-residents, who would for the rest of their university course or courses have the right to use some of the amenities of the hall. To this end it is suggested that some halls might build up a nexus of lodgings in special relationship with them, in which some third- and fourth-year ex-residents would live. The Committee agrees with the usual practice by which the wardens, rather than the administrative officers of a university, select students for membership of the halls.

As already indicated, a senior common room is regarded as indispensable, and the Committee suggests a proportion of one senior resident member of staff for every twenty students. It was impressed by the value of staff houses, adjacent to the halls, for married members of the senior common room; and to meet the shortage of senior members of common room residing in halls it suggests the appointment of 'graduate assistants' to the warden from among postgraduate students, who might receive whole or partial remission of residence fees in return for social or supervisory obligations within the hall. It also believes that the warden and senior members who live in the hall should be entrusted with a greater share in the government than obtains in some universities, and suggests that the internal government of a hall should normally be the responsibility of a hall council, with the warden as chairman and including as members the senior members of the university resident in the hall, with one or two others—possibly a member of senate and, where appropriate, representatives of the graduate assistants. It is also suggested that a joint committee of university council and senate should meet regularly to consider the policy of the university as a whole on student residence, including its educational implications, on which the wardens should at least be well represented. So far as students are concerned, they should be encouraged to take a full share in the management and government of a hall, including the usual committee of elected students for dealing with junior common room affairs.

The key to the success of the hall as an instrument of education, however, lies in the qualifications, personality and status of the warden; in the Committee's view, the character of the hall is largely determined by what he is and does. Good appointments are essential, but there should also be a continuing stream of able candidates for these posts, which, it is urged, should be of such standing that anyone below the grade of professor would regard the office as promotion. Great effort should be made to ensure that the office of warden is recognized as one of value and importance in the educational as well as in the administrative life of the university, and the Committee is convinced that wardens should, wherever possible, be men and women holding an academic post in the university. Adequate clerical help should be available; and halls of 130 or more, where the warden is also a member of the academic staff, should also be provided with a bursar, responsible under the warden for the administration of day-to-day running of the hall.

The Niblett Committee recognizes frankly the impossibility of offering residence to every student of a British university in the near future, and it discusses with some insight the various means of bringing students living at home and in lodgings more fully into university life. Students should be encouraged to spend as much as possible of their day within the university precincts, and facilities for work, meals and leisure activities need to be provided. While the university union supplies many of these, it cannot afford the requisite privacy nor can it handle the numbers soon to be expected in the universities. The Committee therefore suggests that student houses, each under the leadership of its own warden, might be established near the main buildings of universities to serve as non-residential halls or social and cultural centres for an appropriate number of students who are not members of a residential hall. There is clearly room for experiment in such directions, and also for some further probing of the costs of halls as set forth by the Murray Report in 1948. Meanwhile, the Niblett Committee has gone far to establish the educational importance of halls of residence and to reiterate the University Grants Committee's own conclusion ten years ago that the further provision of halls of residence should be a prime object of university policy in Britain during the next decade.

PHYSICAL OCEANOGRAPHY

Allgemeine Meereskunde

Eine Einführung in die Ozeanographie. Von Günter Dietrich, mit Beiträgen von Kurt Kalle. Pp. viii + 492 + 30 plates. (Berlin-Nikolassee: Gebrüder Borntraeger, 1957.) 56 D.M.

THE physical aspects of oceanography have advanced rapidly since the last comprehensive text-book, by Sverdrup, Johnson and Fleming, was written in 1942; of the references in Prof. Dietrich's book nearly two-thirds are to papers published since then. The proportion of new papers is greatest in the sections dealing with the study of the sea bottom, surface waves and internal waves, geochemistry and biochemistry of the oceans, and oceanographic instruments. The study of tides has been established longer than other aspects of marine research, and although there is as much reference to new work in this chapter as in any other there is twice as much to older work. Everywhere the new emphasis is on the physical and mathematical development of the subject.

The main purpose of the book is to give an insight into all aspects of the physics of the oceans, to emphasize the relations between them and to introduce the reader to specialist literature if he needs it. It also deals with the relation of the physics to the biology. It is meant to be an introduction rather

than a handbook. It is written clearly and concisely, and well illustrated with diagrams and pictures. Its tables and graphs are so well chosen that it will serve as a useful reference book.

The effectiveness of modern theoretical and practical methods is illustrated by reference to results obtained with them. The chapter on topography of the sea floor, sediments and morphology describes the results of seismic and echo sounding, coring, and gravity determinations, and discusses density currents, submarine canyons and the history of the oceans. The chapter on physical properties is particularly rich in graphs showing as much as is known about the dependence of the physical properties, including sound velocity and light extinction, on temperature and salinity and other factors. Instruments, energy interchange, currents, circulation, long waves and all other aspects of the subject are admirably dealt with.

To look for faults is being ungrateful, but perhaps it might be better to introduce the idea of a wave spectrum by referring to the now classic paper of Barber and Ursell (*Phil. Trans. Roy. Soc.*, A, **240**, 527; 1948) which showed that there was such a spectrum and that the different wave-lengths travelled according to theoretical expectation, instead of starting with Neumann's ideas. It is perhaps reasonable to expect a text-book which summarizes new progress to do as much as possible to preserve the main features of historical development. "The Oceans" by Sverdrup, Johnson and Fleming seems sometimes to be quoted when reference farther back might be more rewarding. Measurement of currents by the electromagnetic method from a moving ship is mentioned, but it would have been useful to refer to the early paper on "The Electrical and Magnetic Effects of Tidal Streams" by M. S. Longuet-Higgins (*Mon. Not. Roy. Astro. Soc.*, Geophys. Suppl., **5**, 285; 1949) which makes a careful study of the history of the subject, and to that by M. S. Longuet-Higgins, M. E. Stern and H. Stommel (*Pap. Phys. Oceanogr.*, **13**, 1; 1954) which deals comprehensively with the theory. It would also have been useful to refer to Bowden's spectacular demonstration of the practicability of these ideas in the Straits of Dover (*Phil. Trans. Roy. Soc.*, A, **248**, 517; 1956).

These are small defects in an excellent book. Its clear and concise style makes it readable by seamen and others not expert in science, and by students who do not read German very well; but it is to be hoped that someone in Great Britain or the United States will translate it, to make it as widely available as possible.

G. E. R. Deacon

FLOW THROUGH POROUS MEDIA

The Physics of Flow Through Porous Media

By Dr. Adrian E. Scheidegger. Pp. xii+236. (Toronto: University of Toronto Press; London: Oxford University Press, 1957.) 110*s*. net.

THIS book is, to a great extent, complementary to a recent book on the flow of gases through porous media (Carman, P. C., "Flow of Gases through Porous Media". Butterworths; 1957), as it deals predominantly with liquids in single and multiphase flow. The approach is a theoretical one and strictly limited to the physical aspects of fluid flow. The method used is that of a review of existing world literature, with exposition of selected main topics in the form of basic differential equations and discussion of particular solutions of each case. The author gathered the material for the book while working with Imperial Oil, Ltd., Canada, and it originated in a compilation of two thousand references on the subject, of which the author has retained a thousand. It constitutes the best available selection, especially because it includes, for the first time, a great deal of non-Western literature.

The survey of the field is very thorough and therefore extremely valuable, even if a critical appraisal of much apparently similar work is often not given. On p. 145, we read, for example, that "the Klinkenberg equation has been tested by Grunberg and Nissan (1943), Calhoun (1956), Calhoun and Yuster (1946), Heid *et al.* (1950), and Collins and Crawford (1953)". It would have been helpful had the author added that at least one of these contributors was not able to verify the equation and had given an opinion on the observed discrepancies in results.

The author devotes one-fifth of the volume to the all-important structural properties and hydrostatics of porous media, together with the flow of fluids in general. A puzzling statement refers to the critical Reynolds number at which the flow becomes turbulent (p. 26). On the authority of a French and Turkish reference, the author states that this critical Reynolds number is reduced if the direction of flow in tubes becomes increasingly curved. However, British and United States practice (as quoted in handbooks) accepts the work of White and Taylor (*Proc. Roy. Soc.*, A, **123**, 645; 1929: **124**, 243; 1929), which shows that the critical Reynolds's number at which departure from streamline flow takes place increases with the curvature of the tube. There is indeed considerable evidence that, with increasing velocity of flow, streamline flow in curved tubes is maintained much longer than in straight tubes.

In the following chapters, on Darcy's Law and the solutions of the general flow equations, the author is really at home, and the theoretical treatment is excellent. One could only wish that the drag theory of permeability and the general equations for high flow rates could have been more extensively treated, in view of the many empirical equations which have been derived to cover this type of flow. The chapter on multiphase flow gives a scholarly account of the theoretical work available and occupies one-third of the volume.

It is unfortunate that the author has little regard for practical aspects of the problem. Thus, he chooses to describe the original Kozeny model and theory (Chapter 6.3.2), which has been found to give bad results in practice, and only briefly mentions the Carman modification, without giving the derivation, although it agrees with experimental results more often than not. Again, on theoretical studies in the field of relative permeability, the author quotes Rose (1949), whose assumption of textural constants which do not vary with saturation has been shown to be untenable, in view of the experimental results of Wyllie and Spangler (1952). Rose's equations, such as equation 8.5.2.22, should therefore be rejected in favour of the treatment of Rose and Wyllie (1949), which the author does not describe.

On the whole, the book is likely to form an indispensable part of the library of research workers in this field. As a result, the price in Great Britain is relatively high. During its preparation, two works

have been published which are not mentioned in the bibliography: first, the book referred to at the beginning of this notice, the special contribution of which lies in the description of macro surface measurements and in the treatment of molecular flow phenomena during gas flow; secondly, a contribution on porous masses to Volume 2 of "Chemical Engineering Practice" (Butterworths; 1956), which in slightly more than half the pages covers the same field as the book under review but treats the subjects from a chemical engineering angle. PAUL EISENKLAM

BIOPHYSICAL TECHNIQUES

Physical Techniques in Biological Research

Edited by Gerald Oster and Arthur W. Pollister. Vol. 1: Optical Techniques. Pp. xiii+564. 96*s*. 6*d*. (1955). Vol. 2: Physical Chemical Techniques. Pp. xv+502. 91*s*. 6*d*. (1956). Vol. 3: Cells and Tissues. Pp. xv+728. 118*s*. (1956).

(New York: Academic Press, Inc.; London: Academic Books, Ltd.)

THESE volumes contain a large number of articles on the various physical techniques which are applied to biological materials. Such a collection is undoubtedly of value for reference purposes and can be recommended for the reference shelf of nearly all biological laboratories. No doubt much of the information provided could be found elsewhere, but it is often a convenience to have it in one set of volumes which can be consulted rapidly. At the same time there may be some doubt as to the class of reader at which it is aimed. The biologist on the whole will need the help of the physical or physico-chemical specialists in operating many of these techniques; while the specialist will want to look at the original papers.

It is inevitable that a compilation of this sort cannot include the latest developments; and these are often the most interesting. One gets the impression that the editors have made a great effort to include all possible physical approaches. This has resulted in space being given to techniques which are of minor importance, which could with advantage have been omitted.

Turning now to the individual articles, we find in Vol. 1 ("Optical Techniques") articles covering spectrophotometry (visible, ultra-violet and infra-red) which are well done. The chapters on the light microscope and interference microscope discuss the theory of these instruments at considerable length. No doubt biologists would profit from a better understanding of these principles, but it may be doubted whether in fact many would make the study of the physical principles which is required. What would perhaps be more useful is a critical evaluation of the different types of instruments. The section on electron microscopy, although it is suitable for anyone who wanted to become acquainted with the principles and requirements of the method, is inadequate for an electron microscopist.

Vol. 2 ("Physical Chemical Techniques") covers an enormous range of methods, from the use of isotopic tracers and ionizing radiations to surface films and electrophoresis. The article by the late Kurt Stern on electrophoresis is a particularly good survey of practical aspects, up to the time of writing. On the other hand, the information given in the article of Spiegler and Wyllie on electrical potential differences really belongs to a text-book of physical chemistry, and it would have been better to make it more practical and more directed at the biological users.

On the whole, much that is given in these volumes will be found in a good text-book of physical chemistry, and I cannot help thinking that the editors have fallen between two stools. They should either have produced a text-book of physics and physical chemistry in its application to biology; or have limited themselves much more closely to what their title implies, that is, techniques. The chapter on magnetic methods by Scott Blois illustrates the difficulties of this kind of compilation. A reader might well look for information on the developing subject of paramagnetic resonance applied to biological materials; but it is dismissed in a very few pages, and he would be forced to look elsewhere to find out what the method involves in practice and also to find the results obtained up to the present.

In Vol. 3 we come to the applications to real biological systems—cells and tissues. This is in the part of the book which fits the title best and which biologists will find most useful. However, the general considerations given above still apply to some extent. J. A. V. BUTLER

COMPUTERS

An Introduction to Automatic Digital Computers

By R. K. Livesley. (Cambridge Engineering Series.) Pp. viii+53+4 plates. (Cambridge: At the University Press, 1957.) 8*s*. 6*d*. net.

IN this book the author attempts to explain to engineers and postgraduate students the way in which a computer works and its application to actual problems. The book is short and the approach unusual in that the author commences with the programming of simple problems and from a discussion of this aspect of computing leads to an account of the way in which a computer works.

The second chapter is devoted to different kinds of input and output mechanisms and storage organs which are in general use at the present time; the third chapter returns to the programming side with a consideration of the methods of constructing programmes for the solution of specific problems; and the work concludes with an examination of the way in which computers are likely to affect engineers in their approach to different problems.

In such a short book it is, of course, impossible for the author to deal to any great extent with real problems, but those examples given are well chosen and form a good basis for a more detailed study of the subject from other books, and the selected bibliography should help in this way.

The author expresses no extreme views. Some of the statements regarding actual problems might perhaps have been improved by more discussion, notable examples being the remarks on automatic programming (p. 38) and on linear programming (p. 46), but the only real fault in the book lies in the omission of an index.

The author's style, the general production and the material are good, and these together with the low price should make it useful to all students of this subject. A. D. BOOTH

THE NEW ELEMENT NOBELIUM*

PREPARATION OF TRANS-URANIUM ELEMENTS

By H. A. C. McKAY

Head of the Heavy Elements Group, Chemistry Division, Atomic Energy Research Establishment, Harwell

NOBELIUM is the tenth new chemical element beyond the old limit at uranium. Uranium is No. 92 in the sequence, nobelium No. 102. Nobelium is exclusively a man-made element: if any ever did exist in Nature, it must all have suffered radioactive decay long ago. Indeed, all the elements beyond uranium—the so-called 'trans-uranium elements'—are virtually exclusively man-made. Traces of the first two, neptunium and plutonium, are produced in Nature by the action of stray neutrons on uranium, but the quantities are trivial in comparison with those produced artificially.

We have three main tools for synthesizing new elements: the particle accelerator, such as the cyclotron or the linear accelerator, which accelerates small charged particles, such as protons, to high energies; the nuclear reactor, which provides an intense source of neutrons; and the hydrogen bomb, which provides an even more intense source of neutrons for a very short period of time.

Before the War we had only one of these tools, the cyclotron. There were also, of course, rather feeble sources of neutrons in the form of radium, or radon–beryllium sources, but their importance was mainly historical. The heaviest particle which could be accelerated in the cyclotron at that time was the alpha-particle. With such resources it was possible to make two steps upwards in the sequence of elements; starting with uranium (the heaviest then known, No. 92), we could produce neptunium, No. 93, and plutonium, No. 94. This was first achieved in 1940, though there had been earlier erroneous claims to have identified trans-uranium elements, before the fission process was understood.

The resources of 1940 could also have produced element No. 95, americium, though it would have required remarkable insight or good fortune to have carried out the right experiments at that time. What happens is that, after alpha-particles have taken us from uranium to plutonium, Nature comes to our aid by providing a negative, or beta-decay, process that carries us one stage farther still. Not every plutonium atom decays in this way—only the plutonium-241 isotope—and the process is slow, so it is hard to detect what is happening unless it is known beforehand what to look for.

In point of fact, the next advance had to await the building of the world's first nuclear reactors. These machines transmuted the elements on an unprecedented scale, so that by 1944 plutonium had ceased to be an extreme rarity and had become available in gram quantities. It could now be used as a new starting-point, and the next two steps upward could be taken. These gave americium and curium—elements 95 and 96.

Five years later, in 1949, this cycle of events was repeated. The continued operation of nuclear reactors had now produced enough americium and curium for use as cyclotron targets, and elements 97 and 98, berkelium and californium, were prepared. It is rather like climbing Everest. Uranium is the base camp, from which one can move up to the next two camps, or with special skill to perceive a route, to one camp higher still. To get any higher

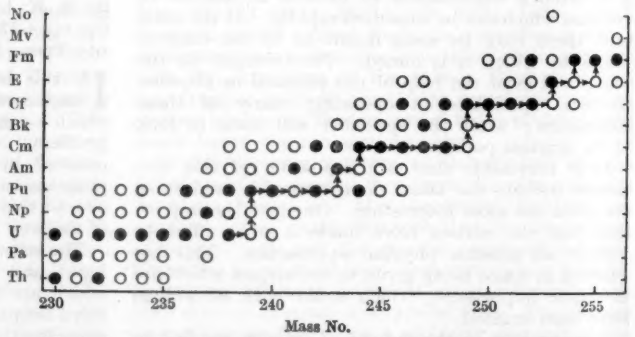

Fig. 1. Sequence of events during the irradiation of uranium with neutrons. Neutron capture processes are represented by a step to the right, and beta-decays by a step upwards

In Figs. 1–4, black circles represent β-stable isotopes; open circles, β-unstable; shaded circles, uncertain

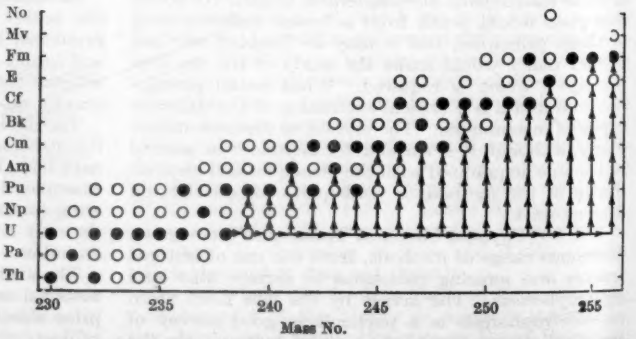

Fig. 2. Sequence of events in a thermonuclear explosion

* Substance of two papers read before Section B (Chemistry) of the British Association on September 9.

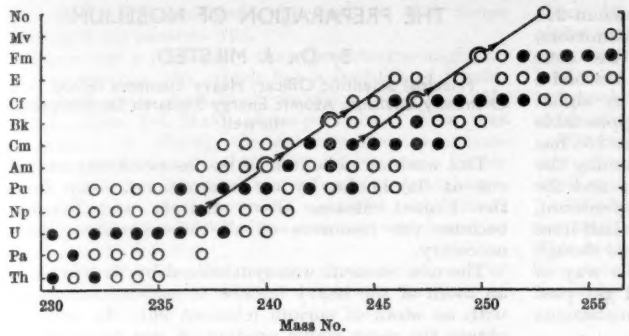

Fig. 3. Examples of heavy-ion bombardment processes

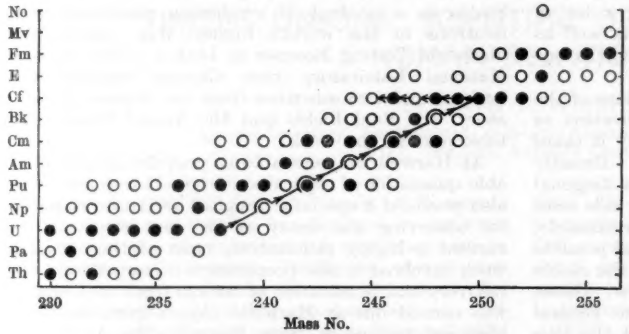

Fig. 4. Stages in a heavy-ion bombardment process

one has to accumulate sufficient supplies at camp II, plutonium. Then one has a further period of build-up before one can progress, and so on; and all the time the atmosphere is getting more and more rarefied. By 1954 the build-up process had gone far enough for the irradiation of californium, No. 98, in a reactor to yield fermium, element No. 100.

Meanwhile, there had been two completely new developments. The first was the explosion of the first hydrogen bomb in 1952. When the debris from the test was analysed it was found to contain both elements 99 and 100, einsteinium and fermium. They had evidently been built up from uranium by a long chain of processes—of successive neutron capture during the very short period of the explosion itself, followed by a more leisurely series of beta-decays. This was a somewhat unexpected result, but it could not be published until 1955 for security reasons.

Meanwhile another new technique was being tried—the acceleration of much heavier particles in the cyclotron. Previously the heaviest particle available was an alpha-particle, and we could only take a two-element step at a time, from, say, curium (No. 96) to californium (No. 98). Now, with carbon ions it was possible to make a jump of six places at a time, with nitrogen ions, seven, and with oxygen ions, eight. Bigger jumps still are likely to become possible in the future, and we can expect great progress when the latest accelerators, designed from the start for heavy ions, come into use.

There was, of course, no security restrictions on publishing the cyclotron work, so it came about that the first announcement of element 99 referred to its production by the bombardment of uranium by nitrogen ions, even though the first discovery was in thermonuclear debris a year earlier. Out of consideration for the true discoverers, the naming of elements 99 and 100 was delayed until the thermonuclear work could be published.

The step to element 101 in 1955 was a brilliant piece of work. In a way it was orthodox—an alpha-particle bombardment of No. 99—but all the techniques had to be pushed to new limits. The latest step, to element 102, will be described by Dr. Milsted.

What are the prospects of further progress? To discuss this question at all adequately we must take a look at the isotope chart as a whole in the heavy region. Uranium-238, the main constituent of natural uranium, is the starting-point for every trans-uranic element. When we irradiate it in a reactor, we get first a single neutron capture leading to uranium-239. This decays by beta-emission first to neptunium-239 and then plutonium-239. This chain is perhaps the most important of all chains of nuclear processes (Fig. 1). But the chain does not stop there. Further irradiation of plutonium-239 gives a very long sequence of products, with neutron capture alternating all the time with beta-decay. With very high irradiations, such as are possible in the world's highest flux reactor, the Materials Testing Reactor (*MTR*) in Idaho, we can get as far as fermium, element 100. In a hydrogen bomb something similar happens. Only this time all the neutron-captures take place first, during the actual explosion, followed by all the beta-decays (Fig. 2).

Heavy-ion bombardment is quite different. It is a matter of a single leap. Fig. 3 shows the leap from uranium to einsteinium under the action of nitrogen ions, and the leap that led to nobelium. The leaps are really rather more complicated than is shown. Take uranium-238 and imagine it being bombarded with carbon-12 ions. First, the two nuclei fuse together to give a compound nucleus, in this case californium-250. But the compound nucleus has a lot of excess energy, and it gets rid of it by boiling off several neutrons, giving lighter californium nuclei (Fig. 4). But one process follows the other so rapidly that we can regard it all as a single leap.

Why can we not push on and on with these different processes, going to higher and higher elements all the time? The reason is that it is like a game of snakes and ladders; by the snakes I mean radioactive decay, which more often than not has the effect of carrying us downwards in the series of elements. The higher we go the more important do the snakes become, and the more difficult it is to dodge them.

Consider again a very high-flux irradiation of plutonium in a reactor. The reactions proceed step by step, with no gaps in the sequence. The members

of the chain are all either long-lived, like curium-244 to curium-248, or they are negative beta-emitters, like curium-249, carrying us upwards to the next element. The chain would be broken if it reached a short-lived isotope decaying, for example, by alpha-decay. This begins to happen to an appreciable extent with einsteinium, because einsteinium-253 has a period of only 20 days. Instead of continuing the chain, some of it decays to berkelium-249; and the process of chain-breaking is in full swing at fermium, where fermium-254 and fermium-256 have half-lives of only just over 3 hr. It looks, therefore, as though fermium represents a practical limit to this way of making new elements. Even if we could get past fermium, we should almost certainly fail two elements later.

There is much more hope in heavy-ion bombardments. Here we have a single leap instead of a chain of processes. So there is no need for a lot of intermediate products to be long-lived, as well as the final one. We go to the final product in one process.

The difficulty here, however, is the direction of the leap. It must always be in some such direction as that shown in Figs. 1–4, and unfortunately it takes us away from the most stable region. Broadly speaking, the most stable isotopes form a diagonal band across the chart, and those on either side tend to decay fairly rapidly. Einsteinium-247, for example, has a period of only 7·3 min. It has several possible decay routes, always leading eventually to the stable band, where decay is almost negligibly slow. Given the position of the band, and given the general direction of the leap, we must try to start the leap from as far to the right as possible; that is to say, we want an isotope on the right-hand edge of the band. (If we went beyond the edge we should be again among unstable isotopes, unsuitable for cyclotron targets.) Uranium-238 is quite a good starting material in this respect—the leap carries us across the band, and not very far out the other side.

We can also control the direction of the leap to a small extent by our choice of isotope for the bombarding particles. For example, we can use carbon-13 or even 14 instead of carbon-12. This enables us to finish up one or even two places closer to the stable band. From uranium-238 and carbon-12, for example, we should get a compound nucleus californium-250, and then californium-245 after boiling off five neutrons. But with carbon-13 we should get californium-251 and -246.

Uranium is, of course, rather low down in the chart, so we are limited in what we can do with it. To improve matters we have two expedients. We may increase the size of the leap, which people are trying to do by using heavier bombarding particles, such as neon ions. The difficulty here is that the longer leap takes us farther into the unstable region. The other expedient is to use a heavier starting material. At the moment, the best available is curium-244, from which the transition to nobelium-253 has been made. In a few years, we may hope to have the higher curium isotopes and californium-252.

Nobody knows what will then be achieved, but it certainly seems possible that half-a-dozen new elements will be synthesized beyond nobelium, before radioactive decay, including spontaneous fission, makes further progress impossible.

THE PREPARATION OF NOBELIUM

By Dr. J. MILSTED

Principal Scientific Officer, Heavy Elements Group, Chemistry Division, Atomic Energy Research Establishment, Harwell

The work on nobelium to be described was carried out at Stockholm by an international team from the United States, Great Britain and Sweden, because the resources of all three countries were necessary.

The new element was synthesized by the fusion of an atom of the heavy isotope of carbon, carbon-13, with an atom of curium (element 96). In order to obtain the most stable product, it was necessary to use the heaviest available isotope of curium. This is curium-244, and it was only available in the United States as a product of irradiating plutonium with neutrons in the world's highest flux reactor (the Materials Testing Reactor in Idaho). The Argonne National Laboratory near Chicago supplied the curium, and two scientists from the Argonne Laboratory, Dr. Paul Fields and Dr. Arnold Friedmann, took part in the work.

At Harwell we were able to provide the considerable quantities of separated carbon-13 required. We also provided a specially designed ionization chamber for observing the decay of the new element. As curium is highly radioactive, most of the chemical work involved in the preparation of targets and the recovery and purification of curium from used targets was carried out at Harwell. Apart from myself, a chemical technician from Harwell, Mr. A. Beadle, also worked on the problem at Stockholm.

The Nobel Institute of Physics, Stockholm, provided the cyclotron, the only one in the world capable of accelerating carbon ions with the required energy and intensity. The Institute also provided a pulse analyser for observing the energy of the alpha-particles emitted by the new element. The Swedish scientists who worked on the problem were Dr. H. Atterling, Dr. W. Forsling, Dr. L. W. Holm and Dr. B. Astrom. In addition, several technicians at the Argonne Laboratory, at Harwell and at Stockholm assisted in the work.

Due to the hazardous nature of the target material and the difficulty of separating a few atoms of the new element from it, a rather new bombardment technique was employed. This utilized the recoil or 'knock-on' effect. A thin layer of curium was deposited on an aluminium foil, and the product atoms knocked out of the target were collected in a plastic film after passing through a very thin aluminium cover foil placed over the curium target, to prevent the spread of curium contamination. The plastic film was ignited on a platinum disk to recover the product atoms. The decay of these atoms could be observed directly, or they could be dissolved off the plate for chemical identification.

A new alpha-activity of 8·5 MeV. energy was observed among the products, and although only seventeen events of this energy were observed with certainty, it was possible to show that the new alpha-emitter had the expected chemical properties for an isotope of element 102. The chemical experiments in each case used ion-exchange techniques. When the activity was absorbed on a column of cation-exchange resin and washed off with a complexing agent (alpha-hydroxy *iso*butyric acid), the

8·5 MeV. alpha-activity appeared in the drops predicted for element 102.

There was a possibility that the activity might be due to thorium-225, which has a half-life of 8 min. and produces a short-lived daughter, polonium-213, which emits 8·4 MeV. alpha-particles. This was eliminated by eluting the activity from a cation-exchange column with 6 *N* hydrochloric acid. Under these conditions, thorium is retained by the column, while the trivalent actinide elements are eluted rapidly. The 8·5-MeV. alpha-activity was found in the actinide fraction.

A graph showing the moment of decay of each of the seventeen atoms observed gave a half-life of about 10 min. for the new activity. The observed alpha-particle energy and half-life, the absence of spontaneous fission, and the method of preparation lead us to believe that the mass number of the isotope prepared is either 251 or 253, the latter number being more likely.

We have suggested the name 'nobelium' for the new element, in honour of the Institute where the work was carried out and also in recognition of Alfred Nobel's encouragement of world science and international understanding. The symbol will be No. This is the first of the trans-uranium elements to be discovered on European soil, and the first to be found by an international effort.

TRADES UNIONS, SCIENTIFIC DEVELOPMENT AND HUMAN RELATIONS*

By LEWIS T. WRIGHT

General Secretary, Amalgamated Weavers' Association, and Chairman of the T.U.C. Scientific Advisory Committee

PROF. K. BOULDING, in "Goals of Economic Life", has said that we have learned in our time that the increase of productivity is a precondition to the abolition of poverty. To-day we accept this principle without question, but in the search for new methods of increasing productivity we find ourselves faced with new problems and related difficulties, from which we have tended to shy away. We have discovered, or rather re-discovered, that the social implications of rapidly increasing productivity, generally expressed to-day in the word 'automation', can become the bottleneck of production, and that unless these social problems are solved in parallel with our technical problems progress will be seriously retarded.

The physicist, the pure scientist, and the technologist have outrun the social scientist in the race for knowledge and 'know-how', and the left hand of knowledge has not known what the right hand has been doing. As Prof. Emerson puts it, "There is too little social science that diagnoses social disease and discovers cures". But these social problems are being forced upon our notice, and the social scientist has quite as important a part to play in helping to achieve an age of plenty as have inventors of the automated factory. The trouble is that there are too few social research workers to cope with the rapidly developing technological changes, and it is very encouraging to know that the Department of Scientific and Industrial Research has recognized the importance of work in this field, and will develop its work in the study of human relations.

People are rather confused as to what are the real implications of the automation age. It is seen by some as a grand cornucopia from which flows a never-ending stream of all the material things of life—a press-button paradise. Others see it as a juggernaut pressing the masses down; a thinking machine eventually conquering the unthinking masses. Neither can be true, but it would be unwise to leave it at that, for there are dangers—social, moral and economic—which need to be examined, indeed, which first need to be discovered. It is the job of the social scientist to discover the evidence, to sift it and to show us how human dignity need not suffer to gain material prosperity.

If this, then, is such a formidable task upon which the social scientists have scarcely yet started, how much more formidable is the task of those who are faced now with the problem of trying to understand workers' reaction in their own plant in the face of change? We need a little more food, and we are looking to the social scientist to produce it for us.

First let me say that the British trades union movement generally accepts the principle that only by increased productivity can higher standards of living be won. I know of no trades union in Great Britain which opposes the principle of automation, but none will approve the development of the machine at the expense of human dignity. This is where the conflict may arise.

The trades union movement recognizes that it has a responsibility to foster productivity, whether it be through the introduction of automated processes or by modern methods of work study. It cannot, nor does it, abdicate its responsibility. To demand, as the Trades Union Congress does, the right to be consulted by the Government of the day on all major factors affecting the economy of our country carries with it the responsibility that goes with such consultation. Last year more than a thousand delegates to the T.U.C. declared their belief that automation can materially improve their standard of living. This does not mean a declaration that they will be prepared to pay any price to get it. The development of the new technique will depend very much upon the price that workers may be asked to pay.

It is true that we want more and more of the material things of life; but many workers are coming to the conclusion that one of the best 'buys' in this modern world is leisure—and that in itself creates serious problems. They are thinking of Continental holidays, for example, with the time necessary to

* Substance of an address delivered to the Institute of Personnel Management at its National Conference in Harrogate during October 4–6.

enjoy them. This is no bad thing, and trades unionists believe that automation and concomitant industrial developments could lead not only to higher real wages, but also to a shorter working week. In other words that automation may enable them to buy not only television, refrigerators and motor-cars, but also more leisure. But we do not believe that the benefits of automation will come automatically to the workers. They will, in a competitive and acquisitive society, have to be fought for. The theory that prosperity is something for which we must work hard now in the hope that some of it will eventually trickle down to the workers does not commend itself to the trades unionist. He wants to be reasonably sure that it is going to mean something to him at the same time as it means something to everybody else.

It is clearly seen, of course, that while the advent of automation will bring problems and difficulties it would be worse if, as a result of insufficient automation, standards of life were reduced because of failure to keep up with the rest of the world in the exploitation of these new developments. It is seen that so long as it is the machine which is exploited and not the worker developments could proceed apace, and increased prosperity come to all. Workers have made up their minds that it must come in this way, and are not prepared to play the part of Lazarus to some automated Dives.

None can say that workers have no reason to fear automation. Since the Industrial Revolution up to recent years, the exploitation of scientific developments in industry has proceeded with a complete lack of consideration for the human being. Human factors have been recognized and ignored. The human factor has been seen as an impediment to progress; an obstacle that somehow or other must be removed. When it could be swept away from the path of industrial progress this has been done. Progress had become a dichotomy. It will be remembered how, in the interests of rationalization and progress, the town of Jarrow was closed down. This rationalization, this progress, meant many thousands of people becoming suddenly unemployed. Acute misery for thousands of families followed. Hunger marches and bitterness ensued—an odd sort of progress indeed. There are to-day millions of working class folk who remember those days, and when the word 'rationalization' or 'automation' is used a cold fear clutches their hearts.

We know that much greater attention is given to-day to the problems of distressed areas and of employment generally. The retraining of workers and transfers from one job to another are becoming more common. Industrial undertakings think twice before closing a factory in the interests of rationalization. Full employment, too, means that in most cases displaced workers can find alternative employment. Despite these trends, many workers think of technical progress as synonymous with unemployment. It is the experience of thousands of workers that technical progress has resulted in the loss of jobs. We are inclined airily to dismiss this line of thought by saying: "In a period of full employment there are jobs for all", as if that settles the issue. Sometimes we say that the workers are wrong in harbouring such fears—and think no more about it.

Our negative reasoning is no better than the negative reasoning of the worker. We must recognize that he does think in certain ways, whether rightly or wrongly, and it is to the interests of industry that we try to understand why he thinks as he does, and to take action to demonstrate that his fears are unfounded. Workers must be shown that industry has as much concern for them as for the machines.

It is the easiest thing in the world to prepare a carefully reasoned statement to prove that a cheaper product stimulates demand and in the long run makes for more jobs. Few workers are interested in the 'long run'. I think it was Keynes who said that we live and die in the short term. Workers live on weekly wages, and in this age of hire-purchase payments, stimulated by advertisements, they budget their income, of which by far the greater proportion goes out in some form of weekly payment. A week or two of unemployment plays havoc with their domestic economy. A month or so of unemployment can break them. Little wonder that the theory of marginal unemployment being an inevitable precondition to bigger and better jobs in the future does not appeal. Their fears have been heightened by stories of 'push-button' factories and electronic brains, and they see not only unemployment facing them but also something nearly as bad, particularly to the older age group—the changing of their job. It is true that full employment cannot mean keeping the same job at the same place. There may be the same job at a different place, or a different job at the same place. Changing skills are inevitable; but so is rain and the sun, and we take steps to protect ourselves from the worst effects of both. To say that there is an alternative job for a man who has spent thirty years in following particular skills may be a rational approach and coldly objective, but from the subjective point of view of the displaced man it is rather a haphazard conclusion, particularly if wages for the new job are lower.

What I am saying is not intended to justify the reasoning of workers, but to recognize that the subjective thinking of workers is based upon experience, and their subjective approach is as logical as the objective thinking of those who can view the 'long term' with a reasonably easy mind.

It would appear that one of our main tasks is to try to reconcile the subjective and the objective approaches to the changes which scientific progress will bring.

What can employers do? With the development of technocracy over the years the word 'employer' has lost much of its meaning. Years ago employers were recognized as persons. Very often they were the owners of businesses, known personally to their workers. To-day the word 'employer' is not personalized, and few workers know who their employers really are. Any loyalty they may have is to something abstract and impersonal. This phenomenon makes it most important that a clear line of adequate communications should flow from top management down to the workers on the shop floor, and equally important from the shop floor up to top management. Lack of adequate communications is probably, as Elton Mayo said many years ago, "the outstanding defect that civilization is facing to-day". The ability of an individual or a group to pass on ideas and feelings to other individuals or groups in a clear and readily understandable way is not given to all. But without this capacity no co-ordinated and co-operative effort is possible. This means in the first place that those who have to do with the leading and directing of labour must be chosen by top manage-

ment with the same care that they put to the choice of new equipment and lay-out planning. To make a mistake in the choice of one can be as serious to the undertaking as a mistaken choice in the other, because it will not do much good to consider carefully the choice of new equipment if you are not likely to get co-operation in its working. As the amount of fixed capital grows, the incidence of labour costs to overheads diminishes, but the importance of labour relations increases, particularly in a period of full employment.

I know of one textile undertaking which has installed ninety-six of the latest type Sulzer looms, each loom costing £3,500. The total capital cost of building, air-conditioning plant, looms and so on was £800,000. The mill works three shifts and employs twelve weavers—four per shift. The wages of the twelve weavers, covering the three shifts at £14 per weaver a shift, are £168 per week. The overheads on capital investment alone, taking 5 per cent interest on capital and 5 per cent amortization, with 250 working days per year, are £325 a day. One weaver off work for a day becomes a very serious matter. For the mill to be stopped for a week will cost the firm employing only twelve weavers at least £2,000 when considering loss of profit and so on. It is true that the problems of industrial relations ought to be solved far more easily with such a small labour force, but the dangers of ignoring these human considerations are shown up the more clearly in cases of a low ratio of labour costs to that of high fixed capital.

If we allow knowledge of scientific and technological progress to outstrip knowledge of human behaviour we are creating for ourselves a bottleneck to productivity. Worker attitude, habit and thoughts are the product of the experience of his kind. Traditions are followed, born of this experience, and if we believe them to be wrong we have clearly to demonstrate in a practical fashion that they can now safely be abandoned. Sound communications can do much to change outlook. Information must be conveyed so that it can be readily understood and readily accepted, and reasons why there should be a change or an experiment should be put clearly enough for it to be accepted. We all know about the Hawthorne experiment, where girls were asked to co-operate in new methods of work. Stuart Chase attributed the remarkable results of the Hawthorne experiment to several factors, the most important being that in asking for the help and co-operation of the girls a change of attitude had been effected. They felt they 'belonged'. They were an important part of an experiment, and had been treated as such. They felt they were no longer just 'human machines'. They had not been ignored. They had been shown the whole picture. Human nature has not changed much since the Hawthorne experiment, and we ought by now to have learned that if workers are treated as human machines or automatons they will behave as such; but if they are treated as intelligent human beings they are the more likely to respond as such.

Attention should be directed to the axiom that people cannot be taught who feel at the same time they are being attacked. Most workers work on the basis that management is guilty until it is proved innocent, and there is a good deal of work to do in this field.

Most of what I have had to say on communications applies to those who are in daily contact with the workers, although top management must set the pace. The problem of redundancy is largely a matter of policy, decided at the very top. It is as necessary for top management to take long-term views in relation to the workers as it is for the workers to take a long-term view in relation to the machines. If workers are to continue to be exhorted to be realists in the problem of productivity, management must be realist in relation to continuing employment and standards of living. They should begin planning against the problems of redundancy at the same time that they begin planning the introduction of new machines. They should be prepared to consult and negotiate, for the workers will feel that as all decisions by management have their impact upon them, particularly in the field of automation, they should be consulted. The wise employer will recognize that joint consultation, effective consultation, is essential if the new plant is to run smoothly. There is plenty of room for improvement in joint consultative concepts and procedure.

So far I have discussed relationships between employers and workers. The Government, too, has a part to play in these exercises. In my opinion, to imagine that the lash of unemployment will assist scientific and technical development is a mistaken view. It could serve only to breed another generation of Luddites. Full employment creates a climate most suitable for the acceptance of change, and it is for Governments to follow policies making for full employment and to allow automation to develop smoothly. They must encourage and sponsor more research, not only in the scientific and technical field, but also in the study of human relations. This, I am glad to say, they are doing through the Department of Scientific and Industrial Research.

The trades unions, too, have an important part to play in this era of change. The trades unions have never been opposed to change. Indeed, they exist to create change—change in the form of higher wages, shorter hours, more holidays; but they want change for the better, not for the worse.

I have already said that the T.U.C. has accepted its obligations in regard to the development of automation, and there exists an appreciation of the fact that our Welfare State can survive only on the basis of continuing and increasing productivity. It is part of our task to educate our members to understand this point of view, and to secure their co-operation in raising the efficiency of industry. The trades unions are doing a good deal in this respect, and are trying to put over the new concepts and the new needs of our age. But I would again point out that "You cannot teach people who at the same time believe they are being attacked". The trades unions can and will play their part, but the main job will be done in the board room and down the line of management. If trade unionists believe they are being attacked, only management can disabuse their minds. The trades unions cannot successfully do that. They can only help. We recognize that greater dangers can arise through automation proceeding too slowly in the United Kingdom while developing more rapidly in the rest of the industrial world. But human values cannot be subordinated to technical efficiency. As a trade union leader I feel it as much my responsibility to bring home this truth to industry as it is to bring economic truths to the attention of my members. The machine is for man, not man for the machine.

BEHAVIOUR AND FATE OF LYMPHOCYTES

LYMPHOCYTES make up a substantial proportion of the leucocytes in mammalian blood. Lymphocytes are not, however, confined to the blood: they are present diffusely throughout the submucosa of the intestine and in the bone marrow; they are the predominant cell-type in the normal lymph node, in the Peyer's patches of the intestine and in the lymphoid tissue in the lung and in the spleen. In pathological material they are particularly associated with areas of chronic inflammation and with certain tumours. Despite this widespread distribution in both normal and abnormal tissues, very little is known about the life-history of the lymphocyte and virtually nothing about its function. The problem is made more striking by the apparently high rate of replacement of the blood lymphocytes; in the rat, for example, the output of lymphocytes from the main lymphatic vessels is sufficient to replace all the lymphocytes in the blood at least eleven times daily. So far as the fundamental properties of lymphocytes are concerned, there would only be agreement that they are motile, non-phagocytic cells which do not respond chemotactically to any stimulus yet tried.

Lymphocytes are produced in the lymph nodes. These are complex structures containing several apparently distinct cell-types: the phagocytic cells lining the lymph channels enable the lymph nodes to filter foreign material from the fluid percolating through them; there is very good evidence that plasma cells are responsible for the production of circulating antibodies; but there is, as yet, no function of lymphoid tissue that can be definitely attributed to its content of lymphocytes.

The problem of the behaviour and fate of lymphocytes was discussed at a Ciba Foundation Study Group held in London on July 23 under the chairmanship of Prof. P. B. Medawar.

The appearance of living human lymphocytes *in vitro* was well illustrated in a film by R. J. F. Pulvertaft (London). The cells were examined in a narrow layer of culture fluid enclosed between a glass coverslip and an agar surface. Time-lapse cinematography showed that lymphocytes often moved towards, and adhered to, malignant cells, to megakaryocytes and to cells of all kinds in mitosis. Having adhered to these cells, the lymphocytes often moved continuously around their periphery, a phenomenon for which the term 'emperipolesis' has been coined. The discussion of this paper centred mainly on whether or not emperipolesis might be an artefact due to the special conditions existing in the agar–cover-slip chamber. G. M. Watson (Harwell) showed that lymphocytes in such preparations will gyrate around glass beads; he suggested that when large cells or glass beads are compressed into the agar by the cover-slip a circular trough is formed around them in which lymphocytes can become trapped. The lymphocytes cannot escape from this trough because, unlike other leucocytes, they will not adhere to glass surfaces; they therefore continue to circle around in it.

The part played by the thymus in the production of lymphocytes was discussed by E. Andreasen (Copenhagen). The high turnover of deoxyribonucleic acid phosphorus and the high mitotic activity in the thymus suggested that it was an important source of the lymphocytes in the lymph and the blood. However, the measurement of the concentration of lymphocytes in the blood and the lymph of thymectomized rats led to the conclusion that very few thymus-lymphocytes leave the organ, and that the production of new cells in it is more or less balanced by a continuous destruction of lymphocytes by the reticulum cells. It was pointed out that the concurrent new formation and disintegration of lymphocytes appears to be a widespread phenomenon in lymphoid tissue. O. A. Trowell (Harwell) described the occurrence of such a process in rat lymph nodes cultured *in vitro*. The histological appearance of these cultures suggested that the reticulum cells were able to phagocytose the remains of dead lymphocytes and then to differentiate into large lymphocytes. The transformation of small lymphocytes into macrophages was also thought to occur, and it was suggested that the small lymphocytes might constitute, in the animal, a reserve of potential macrophages. The discussion showed that the possibility of lymphocytes transforming into other cell-types remains a highly controversial topic.

The transplantation of myeloid and lymphoid tissue was discussed by J. F. Loutit (Harwell) and N. A. Mitchison (Edinburgh). Following a lethal dose (LD_{99}) of X-rays, mice can be induced to recover by an intravenous injection of myeloid cells. Recovery is due to the recolonization of the damaged myeloid and lymphoid tissue by the cells of the donor. When these cells are derived from the same inbred strain, the recolonized animals live nearly as long as normal mice. But when the transplanted cells come from another strain of mice, or from the rat, many animals die 1–3 months later. It was argued that this secondary death was the result of an immunological reaction against the antigens of the host by the transplanted cells. In non-irradiated hosts, transplanted lymphoid cells also become localized in lymphoid tissue. They are capable of immunological activity, for they continue to produce antibody when taken from donors which have been actively immunized. Unless taken from the same inbred strain as their host, the transplanted cells are soon eliminated by the homograft reaction.

L. D. Hamilton (New York) and J. Ottesen (Copenhagen) described the incorporation of radioactive isotopes into the nucleic acids of lymphocytes in the blood. Hamilton administered ^{14}C-adenine to patients with chronic lymphatic leukæmia and isolated the purines from the deoxyribonucleic acid and the ribonucleic acid of the circulating leukæmic lymphocytes. The radioactivity of the purines in both the ribonucleic acid and the deoxyribonucleic acid declined in two phases, rapidly at first, and then slowly, with a very prolonged retention of radioactivity. An analysis of these curves suggested that there were two populations of lymphocytes, one with an average life-span of eighty-five days, and the other with a half-life of about three hundred days. A great deal of interest centred around Hamilton's suggestion that

the prolonged retention of radioactivity in the lymphocytes might not indicate cells with a very long life-span but might be due to a continuous re-utilization of large fragments of nucleic acid or nucleoprotein during the formation of new lymphocytes. The biochemical evidence did not enable a choice to be made between these alternatives, but Trowell suggested that the presence of cell debris in the reticulum cells in lymph nodes could provide cytological support for the idea of re-utilization.

Ottesen described the incorporation of phosphorus-32 into the deoxyribonucleic acid of lymphocytes in the blood of normal human subjects. An analysis of the specific activity curves again suggested the existence of two populations of cells but with shorter life-spans than those calculated by Hamilton for leukæmic lymphocytes: about 20 per cent had a mean age of 2–3 days and 80 per cent a mean age of 100–200 days. There was evidence, both in man and in animals, that lymphocytes may remain in lymph nodes for a considerable time after their formation. Thus, autoradiographs of mouse lymph nodes showed that some lymphocytes labelled with carbon-14 were present in the nodes more than two months after the administration of the isotope.

These experiments with radioactive labels suggested that the life-span of at least some lymphocytes may be considerably longer than was at one time supposed. There was, however, some prejudice against the idea that lymphocytes can live for as long as a year, and, in discussion, this appeared to be a reason for inclining towards the hypothesis of re-utilization.

The problem of the rapid turnover of the lymphocytes in the blood was discussed by J. L. Gowans (Oxford). An apparatus was described for the continuous intravenous infusion of lymph and lymphocytes into unanæsthetized rats with thoracic duct fistulæ. It was shown that there is a direct relationship between the number of lymphocytes entering the blood and the number emerging from the thoracic duct. Thus, the fall in the cell output that occurred on the prolonged drainage of lymph from the thoracic duct could be prevented by the intravenous replacement of all the lymph and cells collected from the fistula. Similarly, after prolonged drainage of lymph, the low output of cells from the thoracic duct could be restored to normal by the transfusion of lymphocytes from other rats of the same inbred strain. A vigorous transfusion of lymphocytes almost doubled the normal cell output of a freshly cannulated rat. The number of lymphocytes transfused could be roughly accounted for by the extra lymphocytes appearing in the thoracic duct lymph of the recipient rat. These effects were most probably mediated by living lymphocytes since the administration of cell-free lymph or of lymphocytes killed by a variety of means had no effect on the cell output. It was felt that the results could not be accounted for by a burst of new cell formation initiated by the transfused cells; they strongly suggested that the apparently high turnover of the lymphocytes in the blood of the intact animal is due to a continuous recirculation of lymphocytes from blood to lymph to blood. This idea was further strengthened by an experiment in which the transfusion of radioactively labelled lymphocytes resulted in their rapid appearance in the thoracic duct lymph.

J. M. Yoffey (Bristol) said that lymphocytes probably recirculated on a small scale via the afferent (peripheral) lymphatics, but that there were a number of difficulties in accepting the hypothesis that recirculation occurred on the scale envisaged by Gowans. Detailed histological observations on the regenerating bone marrow of irradiated guinea pigs tends to suggest that lymphocytes provide a reservoir of stem cells which contribute to the regeneration of marrow.

In the experiments described at the meeting and in discussion it was again made plain that there is, as yet, no real clue to the physiological function of the lymphocyte. Prof. Medawar, in his concluding remarks, expressed the appreciation of those present for the hospitality given by the Ciba Foundation.

ELECTROLYTE PHYSIOLOGY

At the British Association meeting in Dublin, the session held by Section I (Physiology and Biochemistry) on September 9, on "Electrolyte Physiology", opened with a paper by Prof. E. J. Conway (University College, Dublin) on "Energy and Form in the Living Cell". In a paper on so wide a subject, the treatment was necessarily limited to certain aspects, but it includes some basic considerations of ionic permeability of the animal-cell membrane.

The energy requirements of the living cell could be listed under the following general headings: (*a*) maintenance of size and composition; (*b*) special functions such as contraction, conduction and secretion; and (*c*) cell growth and division. The treatment was limited to the first heading, the fully developed cell being considered in general, apart from special functions.

Energy required for maintenance of size with respect to water-content. It is reasonable to suppose that the primitive cell was surrounded by a membrane, necessary to retain substances required for its activities. This membrane is considered to be freely distensible, the comparatively rigid plant-cell membrane developing later as an adaptation to sites with variable mixing of sea and fresh water.

As the membrane may be assumed to exist primarily for conserving essential cell substances, it should have some limiting permeability. If it were quite impermeable to solutes, necessary material would be excluded, without some special expenditure of energy. Passing from such permeability to one in which sodium and potassium ions as well as small anions could enter with equal facility per unit concentration, then, from considerations of osmotic, electrical and Donnan equilibria, the following equation can be written[1] for the equilibrium condition

$$\eta = C - (\varepsilon^2 + 4\Sigma bd)^{1/2}$$

Here η represents moles of non-diffusible material within the cell (using the term non-diffusible with reference to the membrane), ε is the arithmetical sum

of the electrical charges thereon (expressed as m.equiv.), and b and d are external concentrations of a diffusible cation and anion. Assuming the external conditions to resemble that of the internal medium of higher animals, then the value for η or for the essential substances within the cell would be very small, approaching zero, even with zero ε value. But if the permeability were reduced so that while the hydrated potassium ions were allowed to pass the larger hydrated sodium ions were excluded, then with the same conditions the η value would be considerable, even with ε about the same as η. It is to be noted that with such an arrangement there would be high internal concentration of potassium ions and a low or vanishing concentration of sodium ions, and such a relation would continue to exist without any energy being specially directed thereto.

However, it may be supposed that a membrane allowing potassium ions to pass freely will not indefinitely exclude sodium ions, and these will enter slowly along with chloride ions, the cell swelling indefinitely. It would appear necessary, then, for the cell to possess some mechanism to counteract this process, either by the active excretion of water, or of chloride ions, or of sodium ions.

What in fact has occurred is that the cell became endowed with the property of excreting sodium ions, the mechanism being referred to as the sodium pump. As the sodium pump operates in the yeast cell as well as in muscle and nerve fibres of higher organisms, it may be assumed to be a general cellular endowment proceeding from the earliest development of the cell in a marine environment.

Position with respect to plant cells. The argument based on a ready distensibility of the cell membrane does not apply to the comparatively rigid membrane of the plant cell. However, the following considerations may be advanced: (*a*) the kind of cell permeability once established in association with the sodium pump in a fully marine environment and presumably over hundreds of millions of years was retained by plant cells as a fixed endowment; (*b*) the long conditioning to relatively high concentrations of potassium within the cell may have had a secondary effect on enzyme activity; (*c*) the long adaptation to the high concentration of potassium may have required—dependent on the conditions—the active transport of potassium into the cell.

Energy required for maintenance of organic composition. It would appear that the organic and essential non-diffusible constituents of the cell are labile and constantly breaking down, and are then necessarily being rebuilt when the cell is in its resting form or respiring condition.

This continuous process of decay and necessary renewal may well constitute a major fraction of the requirement of resting energy, in unicellular organisms or in the tissue cells of poikilothermal organisms. At the same time, in the unicellular organism, it must be taken into account that surplus metabolism is required for growth and cell division, this being essential for the survival of the species.

In certain cell states, as in spores and seeds, associated with a comparatively high degree of desiccation, the breakdown process may be indefinitely suspended, and there are authenticated instances of seeds germinating in suitable environments after lying dormant for centuries.

From a quantitative point of view the non-diffusible and labile components of the cell in general consist very largely of protein and various phosphate esters, much the greater fraction being protein. Here the principle may be entertained that no non-diffusible constituent of the cell is present without functional significance, which would imply that if all the functional non-diffusible material were removed from the cell, nothing is left, except water and salts. But what functional significance is to be attached to cellular protein, ignoring the specialized function of certain fibres? The answer that naturally arises is that, in general, the total protein of the cell is nothing more than the sum of its enzymes; an answer that must have occurred to many workers independently.

Cellular size levels and energy exchanges. Here it is initially helpful if only in a tentative way to consider the advantages and disadvantages that may arise from a diminution of cellular size proceeding from a given level. The following advantages may be mentioned: diffusion of substances necessary for metabolism throughout the cell becomes more rapid; interaction of rapidly acting respiratory redox systems is facilitated; and the entrance of necessary material and excretion of waste products are promoted. At the same time disadvantages of the following kind arise: other things being equal, the rate of entrance of sodium into the cell is increased and so is the work for the sodium pump; while below a certain critical size it may be supposed that each single cell can no longer have the totality of enzymes necessary for its full metabolic life.

Considering the more important aspects of these, it may be noted that, for the functioning of the rapidly acting respiratory enzymes, it would seem that the smaller the cell the better, down even to bacterial size; but for minimizing the work of the sodium pump, and what is probably more important, for achieving the necessary complement of enzyme molecules, a certain critical size, greater than that of bacteria, may be expected.

What in fact happens is of great interest in the light of such considerations. The respiratory enzymes inside the cell are almost entirely incorporated in bacteria-like particles termed mitochondria, and are surrounded by a more extensive cytoplasm. Thus the maximum advantage would appear to be obtained, but not by the apparently obvious device of a critical size governed by a balance of advantages with disadvantages.

Cellular size relative to total energy exchanges. This can be well examined by comparing the sizes of cells of the same tissue-type throughout the great range of adult body-weight in the mammalia. Years ago, I assembled data[2] from the literature relative to the size of the nephron cells and other associated data for several species with a total range in body-weight of a factor of 20,000 (mouse to horse or cow). The surprising fact emerged that the size of the nephron cells was quite independent of the body-weight, but it could be shown that the total effective work done by the single cell is approximately the same. An interesting series of relations was established, and which within the sampling error could be written

$$V = \alpha \times W^{0.666} \qquad g = \delta \times W^{0.111}$$
$$n = \beta \times W^{0.444} \qquad d = \varepsilon \times W^{0.000}$$
$$l = \gamma \times W^{0.222}$$

where W is the body-weight, V the average volume of urine, n the number of glomeruli, l the length of the

first convoluted tubule, g the diameter of the glomerulus and d the diameter of the cell, with α, β, γ, δ and ε constant relative to W. An explanation of these relations was then essayed, which with some modifications would still appear valid.

I also included a brief account of free-energy exchanges within the cell, including the formation and significance of energy-rich phosphate bonds and the thermodynamic theory of the redox pump, which has been incorrectly treated in some recent publications.

Mitochondria and ion transport. The question of ion transport in mitochondria was taken up by Dr. M. G. Harrington (University College, Dublin). The name mitochondria, signifying 'thread' and 'granule', was given by Benda[3], who observed them as filaments or as small rods or granules both in the living cell and in fixed sections.

Mitochondria in the living cell appear to be in a state of constant movement, either a wriggling motion or a transposition from one part of the cell to another, and from the nucleus, for example to the cell membrane and back again[4].

In the isolation of mitochondria from homogenized tissue it is important to observe certain conventional conditions for their separation by centrifugation[4]. Bensley and Hoerr[5] and Claude[6] were the first to stress this point, which was developed very fully by de Duve and Berthet[7]. Concerning the functions of mitochondria there were some early pointers strongly suggesting their connexion with cellular respiration, and at present it would appear from the work of Schneider and Hoogeboom[8] that they are the site of the electron-transporting system and in particular of cytochrome oxidase. From the work of Green[9], Harman[10], de Duve and Berthet[7] and others it appears that they are also the site of oxidative phosphorylation and the enzymes of the Krebs cycle.

While the major significance of mitochondrial study lies with the location of enzymes within the cell, their linkage with respiration and their movements have induced several workers to examine their possible role in active transport.

The kind of active transport contemplated for animal-tissue cells is that of the sodium ion, since for muscle, gland and nerve the evidence is very strong that the fluxes of potassium are of a passive kind. Apart from questions of active transport it is also of importance to ascertain exactly how much potassium and sodium are associated with the mitochondria.

An essential prerequisite to any such study would be the determination of the extraparticulate fluid volume. Theoretically this could be expected to have a maximum value of 26 per cent, corresponding to the value for rigid spheres[11]. Using inulin, data in the literature show values as high as 66 per cent[12], which apparently can be interpreted only on the basis of an entrance of the inulin into the intramitochondrial water, presumably in varying amounts depending on the experimental conditions. In this department, inulin, sucrose and thiocyanate were used to study the extraparticulate volume, all three methods giving extremely high values. A closer study of the permeability of the mitochondria to thiocyanate yielded anomalous results which were therefore disregarded. When the mitochondria were rendered sucrose-free, by washing with saline prior to the estimations, serial values were simultaneously obtained, the thiocyanate value being of the order of 70 per cent, that for sucrose 50 per cent while that for inulin was only 20 per cent. These figures may well point to a compartmented structure for mitochondria as visualized by Werkheiser and Bartley[13], and as might be expected from the many electron micrographs of mitochondria clearly showing the existence of internal membranous structures. The significance of the effect of washing in saline is not clear, but it may point to the need for further experiments using solutions closely approximating to cell-fluid itself as the ideal preparative medium for the isolation of the mitochondria.

Hormonal control of electrolyte metabolism. Finally, Dr. D. Hingerty read a paper on the control of electrolyte metabolism by hormones. The secretion of the posterior lobe of the pituitary and that of the adrenal cortex appear to exert a direct control over water and electrolyte exchanges in the body. In recent years much new information on the functioning of these glands has been obtained. The active principles of the posterior lobe have been isolated and their structure established[14]. They are two octapeptides, which have now been synthesized, and are closely related structurally. One is responsible for the antidiuretic and pressor activities, whereas the other has oxytocic functions.

Originating in the hypothalamus, these factors are stored in the posterior lobe and liberated as required in response to changes in plasma volume, electrolyte concentrations in plasma and other stimuli.

The processes whereby the adrenocortical principles are synthesized and released into the circulation have now been deduced in some detail, the final products (mainly corticosterone and 17-hydroxycorticosterone) being produced after condensation of 2-carbon fragments into squalene and cholesterol, successive alterations of the cholesterol molecule being brought about by enzymes located in various components of the adrenocortical cells[15]. These reactions are greatly accelerated by adrenocorticotrophic hormone, but the mode of action is obscure.

In recent years much work has been done on the isolation and investigation of aldosterone[16], a remarkably potent hormone with respect to electrolyte exchanges. It has some unique properties in structure and mode of secretion, its release into the circulation being determined more by levels of circulating electrolytes[17] (especially potassium) than by adrenocorticotrophic hormone.

The antidiuretic and adrenocortical hormones would appear to act (with respect to water and electrolyte exchanges) mainly on the kidney tubule, but a more general action on sodium and potassium exchanges exists as judged from effects on the isolated frog skin[18] and even on fermenting yeast cells[19].

If, in the mammalian nephron, the most prominent action of the adrenocortical hormones is an inhibition of potassium absorption (as happens in fermenting yeast) then, after adrenalectomy, more potassium would be absorbed with a rise in the content of potassium in the plasma. The hypothesis may then be entertained that the increased uptake of potassium ions has an inhibiting effect on the re-absorption of sodium ions, by displacing sodium from the carrier complex. As a result the plasma sodium would tend to fall. With a high concentration of sodium down the nephron lumen such effects may be expected to be minimized. In this way some of the major facts on the inorganic electrolyte distribution of adrenal

insufficiency and high intake of sodium may be interpreted[20].

With regard to the rather arbitrary division of the cortical hormones into 'mineralocorticoids' and 'glucocorticoids', it is to be noted that even the very potent 'mineralocorticoid' aldosterone has considerable 'glucocorticoid' activity, the difference between the two groups of hormones being quantitative rather than qualitative. The changes in inorganic content of the cells may modify certain enzymatic actions connected with normal organic metabolism, and in this way the increases of magnesium in plasma and cells which accompany the increased level of potassium after adrenalectomy[21] are of much interest. The increase in magnesium content of muscle fibres is associated with an increase of adenosine triphosphate and phosphocreatine, presumably by inhibition by magnesium ions of adenosine triphosphatase and of phosphokinases. Here one may well have a link with the depression in muscular activity, and of growth and heat production seen in adrenal insufficiency.

E. J. Conway

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SOME ASPECTS OF MICRONUTRIENT ELEMENT METABOLISM IN PLANTS*

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Experimental methods and problems. At present ten micronutrient elements, iron, manganese, copper, zinc, boron, sodium, molybdenum, chlorine, vanadium and cobalt, and six macronutrients satisfy criteria of essentiality for some plant organisms. Quite recently, recognition of molybdenum, chlorine[1] and vanadium[2] resulted either from the use of pure salts initially, regardless of later treatments, or from observation of growth increments due to vanadium in unpurified ferric chloride or to chloride provided by cobalt chloride. Further knowledge may depend on avoiding contamination in containers, water, reagents[3], seeds and the atmosphere[1]. Levels of deficiency shown recently for chloride[1], sodium, and vanadium[2] appear to exceed greatly those of 5×10^{-6} p.p.m. or less necessary to show a deficiency of molybdenum[4,5]. Since there may be about 10^3 atoms of molybdenum in deficient cells[6] it may be necessary further to decrease the supply of some elements by a factor of 10^3 before judging requirements, though negative results cannot be decisive. Total or partial replacement between elements, for example, calcium/strontium, molybdenum/tungsten, molybdenum/vanadium, potassium/rubidium/sodium, or of function, as in the case of molybdenum in nitrate reduction[7], which can be bypassed[8], may modify absolute, as well as quantitative, requirements.

Effects of micronutrients on growth. Mineral deficiencies and excesses have reproducible effects of diagnostic importance in many plants, and reflect reproducible metabolic states. Diverse symptoms may appear in different species, although the roles of many elements are probably general. The diversity may result from quantitative differences between plants in the distribution and activity of particular systems during growth, especially where two or more related enzymes depend on the same metal, or in qualitative differences in metabolism. Thus, the lesions in barley deficient in potassium are due to accumulation of putrescine, which is not observed in flax. Large changes may occur in the levels of free amino-acids and amides[9–12], especially with deficiency of zinc[11]. The pattern produced may vary with both deficiency and plant, and L+isoleucine and L hydroxyproline may induce severe abnormalities.

Indoleacetic acid 'oxidase'. A mechanism for the oxidation of indoleacetic acid occurs widely. Early experiments suggested that a hæm enzyme, possibly peroxidase, was involved and that some interaction occurred with manganese. Galston and others[13,14] suggested that the 'oxidase' system in pea epicotyl comprised a flavoprotein and a peroxidase that mediated a peroxidative reaction between the product of the initial oxidation by the flavoprotein, and hydrogen peroxide produced in this first step, which was regarded as photosensitive; the crude action-spectrum suggesting that of riboflavin. Kenten[15] and Stutz[16] showed that purified peroxidases and a monophenol co-factor comprised 'oxidase' systems without any flavoprotein component. Waygood and associates[17,18] have elucidated several points. The manganic ion, when stabilized as manganiversene, initiates non-enzymic decarboxylation and is reduced to the manganous form. The liberation of a hydrogen ion and a skatole free radical (I) is inferred. This is assumed to take up oxygen spontaneously to form a free radical of a skatole peroxide (II). In the presence of a peroxidase this oxidizes a monophenol co-factor which regenerates a manganous ion by the Kenten and Mann system[19], and yields a stable yellow product (III). The autocatalytic reaction is initiated by traces of manganic ion generated by various means

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—such as light and riboflavin, or scopoletin, resorcinol and peroxidase[16], or illuminated chloroplasts—and is observed *in vivo*.

The effect of manganese is complex and specific[16]. Inhibition may occur in citrate buffers[14,16] or in crude extracts. Stimulation may occur over a wide range[16,18] in phosphate buffers, depending on the presence of monophenol co-factors or following lag-periods in the uptake of oxygen[15], which may invalidate observations made over single intervals of time[14]. The diverse effects of manganese are related to competition for peroxidative capacity, between the indoleacetic acid/monophenol/manganous ion system and O-diphenols which reduce[19], or citrate and pyrophosphate which inactivate, trivalent manganese[16,19].

The nature of the reaction products, the role of peroxidase and the production of hydrogen peroxide require re-examination. The reaction involves the uptake of one mole of oxygen and production[16] of one mole of carboxyl carbon dioxide for each mole of indoleacetic acid oxidized[15,16,18]. Several products may occur[16], although a yellow one (III), apparently identical with that obtained non-enzymically, may predominate[18]. One or more products may contain a carbonyl group and the indole configuration[16], and possibly a phenolic group. The production of a hydroxy-amino-acetophenone with formate and carbon dioxide demands the uptake of 1·5 *M* of oxygen and does not account for peroxidase action. The production of a 3 methyl 2, 3-dioxindole, $C_9H_9O_2N$, *via* a hydroperoxide does not account for a peroxidative step and implies non-oxidative decarboxylation, which is contrary to evidence for the reduction of trivalent manganese[17]. Waygood and others[18] suggest the formula $C_9H_9O_2N$ for the yellow product (III). A weakness of their scheme is that the normal peroxidative mechanism is replaced by transfer of hydrogen from the monophenol donor to an organic peroxide (II), which retains all its oxygen without the production of water or of a hydroxyl group.

An alternative idea is that the postulated skatole free radical (I)[18] undergoes rearrangement, forming a methylene group and a nuclear free radical (IV). The uptake of oxygen producing a peroxide (V) might, with peroxidase, yield a stable carbonyl product C_9H_7ON (VI), with the indole structure, and give peroxidase II directly without formation of peroxidase I, as found for the dihydroxymaleic oxidase mechanism. This would be consistent with reactions between peroxidase and oxidizing agents other than hydroperoxides, which yield peroxidase I and II. Peroxidase II, which has only one oxidizing equivalent, could regenerate one manganic ion for each cycle[19]. Enolization might produce a hydroxyl compound (VII) accounting for two similar compounds. Non-enzymic reaction between the skatole peroxide (V) and indoleacetic acid, as postulated by MacLachlan and Waygood[18], could yield the same product (VI) as with peroxidase. For autocatalysis, trivalent manganese must be formed in excess of the initiating trace. The reactive free radical peroxide (V) might react either with a monophenol directly as postulated[18], giving a semiquinone equivalent to one manganic ion and a hydroperoxide (VIII). This might produce peroxidase I with two oxidizing equivalents, able to generate two manganic ions and also yield a third compound (IX), C_9H_9ON, with a hydroxyl group, potentially forming an ideal peroxidase substrate, which would be converted to (VI) at the expense of trivalent manganese by competing with the monophenol for peroxidase I and II. The proportions of (VI), (VII) and (IX) would not affect the stoichiometric requirement for 1 mole of oxygen and would depend on the availability of monophenol, manganese and peroxidase. The oxidation-reduction potential and stability of the manganic compound, such as the versenate, may be critical[17]. Natural monophenols may stabilize trivalent manganese with the correct potential[17], and form a co-factor complex for the 'oxidase' system. Whether hydrogen peroxide is formed is uncertain. Pure or dialysed catalase can replace peroxidase at *p*H 5–6·3[16], but catalase or colloidal platinum may inhibit at *p*H 6·5–7·0[15]. The quenching of fluorescence of scopoletin during indole acetic acid oxidation and adaptive peroxidase production in response to indoleacetic acid do not preclude organic peroxide action.

Molybdenum nutrition of plants. Plants deficient in molybdenum and grown with nitrate show many effects[21,22] that can be explained by the role of molybdenum in nitrate reductase[7]. Other effects not apparently related to low nitrate reductase activity also occur, including generally decreased ascorbic acid[23], decreased sugars in cauliflower, decreased organic/inorganic phosphate ratios in tomato and cauliflower[24,25] and apparently increased content of adenylic acid in cauliflower.

These changes are generally independent of the source of the nitrogen used to grow the plants[10,21,22]. Deficiency of molybdenum increases levels of certain amino-acids in cauliflower, given ammonium compounds, urea, or glutamic acid, whereas chlorophyll content is scarcely affected. The leaf malformation of cauliflower known as whiptail[20] occurs with deficiency of molybdenum with all nitrogen treatments[22]. With nitrate nutrition, whiptail occurs with a critical supply of molybdenum which allows considerable nitrate reduction but is inadequate in some other respect. Oxidation of ascorbic acid in cauliflower leaf and acid phosphatase activity in tomato are apparently increased by deficiency of molybdenum, whereas dehydrogenase action may be less. Nitrate reductase may be adaptive in fungi[26] and cauliflower[27] in regard to supplies of both molybdenum and nitrate (or nitrite). Attached and excised tissues of cauliflower, deficient in molybdenum and grown with ammonium sulphate, require molybdenum and nitrate for a production of enzyme which can be detected after a lag-period of one or two hours. Addition of molybdenum to cauliflower leaf disks[28] increases the respiratory quotient during reduction of accumulated nitrate after a similar lag-period. Addition of molybdenum to deficient tomato plants grown with nitrate causes increase in nitrite after a lag-period of about one hour[29], and levels of free amino-acid increase after an *initial decrease* during the first hour[13]. These changes are consistent with synthesis of an adaptive enzyme. Suppression of light for 4–6 days or air for 48 hours[27] also depresses the activity of nitrate reductase, which recovers rapidly on restoring normal conditions. Absence of an inductive metal constituent required for the synthesis of a specific enzyme may release template sites for abnormal competitive synthesis of other enzymes, or molybdenum may fulfil more than one specific role. In *Scenedesmus obliquus*[3] vanadium may have acquired one function usually fulfilled by molybdenum, since both elements are needed together with nitrate, whereas molybdenum may be unnecessary with urea or ammonium carbonate in this organism[3].

Multiple metal activation and differential enzyme activity. In enzymes of the tricarboxylic acid cycle optimum requirements of manganese *in vitro* range from about 10^{-3} *M* for 'malic' dehydrogenase and oxaloacetic decarboxylase in parsley root to about 5×10^{-4} *M* for isocitric dehydrogenase in *Avena* coleoptile or *Phaseolus* leaf. Cobalt at $7{\cdot}5 \times 10^{-4}$ *M* is equivalent to manganese in one enzyme, but at 4×10^{-3} *M* gives only 55 per cent of the value for manganese in another and is toxic to glutamic dehydrogenase in *Avena*, whereas magnesium at 10^{-3} *M* and 10^{-2} *M* gives 80 and 10 per cent respectively of the values for manganese. Manganese at 3×10^{-3} *M* is specific for the reduced triphosphopyridine nucleotidase in wheat germ, whereas manganese or magnesium at 4×10^{-2} *M* is equivalent for the reduced triphosphopyridine nucleotide glutathione reductase. Isocitric, malic and glucose-6-phosphate dehydrogenases can be linked to glutathione reductase in many plants[30], but show unrelated activity over a wide range. The effects on the malic and isocitric systems of adding manganese *in vitro* vary greatly, from 15-fold increase to slight inhibition[30]. Similar differential effects occur with hexokinase, phosphohexokinase, and 2–3 diphosphoglyceric phosphotransferase in several plants where magnesium and manganese are interchangeable, and cobalt can activate the last. Nineteen enzymes activated by magnesium in yeast attain 50 per cent of maximum activity between about 3×10^{-3} *M* and 4×10^{-5} *M*. The absence of marked optima permits maximum activity at 10^{-3} *M* in seventeen of these enzymes, but riboflavin phosphate pyrophosphorylase is then decreased to 50 per cent of maximum. Manganese may replace magnesium in at least fourteen enzymes with an efficiency ranging from less than 30 per cent, to one equal or nearly double that of magnesium, whereas cobalt *in vitro* replaces magnesium at double its efficiency in riboflavin kinase. Competitive inhibition by activating metals also occurs, and certain concentration combinations may be unfavourable. These examples also suggest reasons for diversity in the requirements for micronutrients and in the symptoms of deficiency.

Mineral deficiencies and enzyme pattern. Organisms deficient in certain minerals may lack activity of enzymes directly dependent on the deficient element. Deficiency during growth appears to prevent synthesis of the metalloprotein enzymes and no reactivation occurs on adding the metal to the *extract*[26,27,31]. The dissociable isocitric and malic enzymes, however, may be present though inactive in the *extract* from a deficient plant and are reactivated on adding the metal[28]. Differential decreases in activity may occur under conditions of deficiency when several enzymes depend on the same metal.

Enzymes not dependent on the deficient element may show greatly increased activities[31–33], which decrease to normal in 2–6 days when the deficiency is corrected, while the activity of the respective metallo-enzymes is restored[31]. Increases in peroxidase with deficiency of zinc[31], or in phenol oxidase with deficiency of boron[31,34], appear consistent in many plants, but trends may also vary. Several deficiencies may produce a similar change in one enzyme, such as acid phosphatase or peroxidase[31]. Interactions between antagonizing elements, such as cobalt and iron[35], or iron and manganese, may show analogous effects. Some mineral disorders may reflect the integrated effects of such abnormal but reproducible enzyme patterns.

The changes in the amino-acid pool might be expected to affect enzyme synthesis, but present evidence does not support this idea. The lack of one enzyme might cause adaptive increases in others due to increases in substrates for alternative systems. The accumulation of chlorogenic and caffeic acids in plants deficient in boron[36] might increase polyphenolase activity[31,34]. *Neurospora* deficient in zinc contains negligible alcohol dehydrogenase[33]. Several dehydrogenases linked by diphosphopyridine nucleotide[37] appear to be zinc metallo-enzymes and much of the diphosphopyridine nucleotide may be bound by the enzyme[38]. If these points apply to *Neurospora*, an adaptive increase in diphosphopyridine nucleotase[33] might result from increased free diphosphopyridine nucleotide due to non-synthesis of the apo-enzymes. It has recently been reported[39] that diphosphopyridine nucleotase activity is greatly decreased for bound diphosphopyridine nucleotide on active glyceraldehyde-3-phosphate dehydrogenase.

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OBITUARIES

Prof. H. U. Sverdrup

HARALD ULRIK SVERDRUP, who died very suddenly on August 21, was born in November 1888. He was a relative of Otto Sverdrup, who had been Nansen's captain on the *Fram* and who was himself the discoverer of a great fjord region west of Ellesmere Land.

Sverdrup became assistant to Prof. Bjerknes in Oslo in 1911, but during 1913–17 studied in Leipzig. From 1917 until 1925 he was leader of research on the *Maud* Expedition led by Roald Amundsen and during this period obtained an intimate knowledge of the Arctic. He was appointed a Research Fellow at the Carnegie Institution of Magnetic Research in 1922. From 1926 until 1931 he was professor of meteorology in the Geophysical Institute in Bergen. In 1931, when Sir Hubert Wilkins planned an expedition towards the North Pole in the submarine *Nautilus*, Sverdrup gave him full support. Unfortunately, apart from dives at the edge of the sea ice, Wilkins was never able to carry out his plans and the submarine was scuttled off Bergen in November of that same year. In 1934 Sverdrup took part in an expedition to North West Spitsbergen, with his close friend, Prof. H. W. Ahlmann, to study heat exchange between the atmosphere and the snow surface in these high latitudes. Sverdrup was appointed director of the Scripps Institution of Oceanography in California and was professor in the University of California during 1936–48. He was invited to become director of the Norwegian Polar Institute in 1948 and in 1949 became professor of geophysics in the University of Oslo.

H. U. Sverdrup's career was quite unusual, and there is no one else who has ever combined a special knowledge of mathematics and physics with familiarity in the field with problems both in the Antarctic and in the Arctic. He is known to a very large number as one of the three authors, the others being Martin W. Johnson and R. H. Fleming, of "The Oceans", published in 1942, which will long remain the most extensive text-book on oceanography. He is equally well known, however, to the smaller number who have been associated with him in polar science. Sverdrup was responsible for the home control of the Norwegian–British–Swedish Expedition to Queen Maud Land in 1949–52, and himself visited Maudheim in January 1951. His polar knowledge was extremely varied. Anyone anxious to obtain information, for example, on sea ice would rely very largely on Sverdrup's opinion, and his views on this subject were invaluable at the time that the Royal Society's Expedition to Halley Bay was under consideration. This, however, was only one of the many fields of rare and unusual knowledge which he covered and which have made him unique among explorers.

J. M. WORDIE

Prof. W. N. Benson, F.R.S.

WITH the death on August 20 of emeritus professor W. N. Benson, of the University of Otago, New Zealand has lost the doyen of her geologists. He passed away after a brief illness, although his general health had given concern for some time.

William Noël Benson was born near London on December 26, 1885, the son of an Australian shipping manager. He was educated at the Friends' High School in Hobart and later at the University of Hobart and the University of Sydney, where he came under the influence of the inspiring personality and teaching of Sir Edgeworth David. While still at Sydney, and before even graduating B.Sc. in 1907, he published a paper on the contact aureole of a granitic body. This early irruption into the field of original inquiry initiated a career that was always devoted primarily to research. The topics he investigated were to involve work in virtually all the geological sciences, though he made especially significant contributions on the interplay of tectonics and magmatism. His work was followed with extraordinary energy, enthusiasm and persistence. All his former students will remember his well-loved figure forging ahead in front of panting field-parties, and in his office, when too tired for other work he would turn to drafting maps and block diagrams, an occupation which, he maintained, did not require great mental effort. He handled a very heavy teaching load, being professor of geology in the University of Otago without any assistant during 1916–26 and with only one assistant (F. J. Turner) for all but three of the remaining years before he retired from active teaching at the end of 1949.

In 1908 Benson acted for a year as lecturer in mineralogy and petrology in the University of Adelaide. Three papers followed, two of them on petrological problems and one on the fault-block structure of the Mt. Lofty Ranges. Back in Sydney during 1909–11 as demonstrator in petrology, he began his classic study of the geology and petrology of the Great Serpentine Belt of New South Wales, which he continued first as 1851 Science Research Scholar at Cambridge under Harker, Bonney and Marr (1911–13), and later (1914–16) as Research Fellow and lecturer in Sydney. The resulting long series of papers culminated in two notable publications that appeared after his appointment to Otago—"The Origin of Serpentine" (1918) and "Tectonic Conditions accompanying the Intrusion of Basic and Ultrabasic Igneous Rocks" (*Mem. U.S. Nat. Acad. Sci.*, 1926).

In Dunedin, he quickly turned his attention to problems of New Zealand geology as well as its relation to the south-west Pacific as a whole. He carried out important researches on New Zealand's then little-known Ordovician rocks and on their graptolite faunas. His geomorphic observations in Fiordland and in the Dunedin district led to the important concept of both a Cretaceous peneplain in the South Island, and a late Cainozoic erosion surface truncating it and later sediments. He also showed that the so-called block mountains of eastern Otago are essentially fault-folds of more or less Saxonian type. His last major discovery was that of the first Cambrian rocks to be found in New Zealand, a brief account of which was published shortly before his death. Benson's major work in New Zealand, however, was undoubtedly his long and detailed study of the late Cainozoic East Otago Petrographic Province. Numerous papers on this and on related topics have already appeared, but a comprehensive memoir is still to be published. Progressive crustal movements are shown to have occurred during the

eruption of repeated differentiation cycles of basic and alkaline volcanic rocks.

During his life-time Benson received many honours. He was a foundation Fellow of the Australian and New Zealand Association for the Advancement of Science, and its Mueller Medallist (1951); Fellow of the New Zealand Institute, later Royal Society of New Zealand (1926); Hector medallist (1933), Hutton medallist (1944) and president (1945–47) of the same Society; Lyell medallist of the Geological Society (1939); Fellow of the Royal Society (1941); Clarke medallist of the Royal Society of New South Wales (1945); correspondent of the Geological Society of America (1949); honorary D.Sc., University of New Zealand (1951), and honorary member of the Mineralogical Society (1954).

Benson looked upon himself as a geological child of Sir Edgeworth David, and he always spoke of his old chief with the greatest reverence and affection. There is now another geological family, that of W. N. Benson himself, whose members are spread throughout the world. He has left them—and science as a whole—well over a hundred published memoirs, papers and notes recording his researches and his scientific philosophy, written in his own characteristic style. Above all he has left them the memory of himself, which lives on in the ever-widening circle of his geological descendants.

He is survived by his wife, formerly Miss Helen Rawson, who was professor of home science in the University of Otago at the time of their marriage in 1923.

D. S. Coombs

Dr. Charles Todd, O.B.E., F.R.S.

Charles Todd died at Croydon on September 22. He was born in 1869, coming of farming stock in Cumberland. After ill-health as a small boy, he received an education, mainly classical, at Carlisle Grammar School, but succeeded in obtaining an open scholarship in physics and chemistry at Clare College, Cambridge, in 1888. In due course he obtained a Class I in the Natural Science Tripos, proceeding to St. Bartholomew's Hospital with an open scholarship and qualifying in 1894. After several clinical appointments he became interested in public health problems while working at the London Fever Hospital. In 1900 he became assistant bacteriologist to the serum department of the Lister (then Jenner) Institute and worked on antitoxins with George Dean and later G. F. Petrie. Here he demonstrated the existence of a toxin produced by Shiga dysentery bacilli. He went to Egypt in 1904 to help to make antisera against cattle plague, of which there was a serious outbreak there. This led to an appointment as bacteriologist and afterwards director of the Hygienic Institute in Cairo, and he finally spent twenty-one years in Egypt. In 1906 he was investigating scorpion venom and found out how to make an antiserum. But cattle plague remained a major interest and he made valuable contributions to our knowledge of the disease.

His most important scientific work arose incidentally out of this, for, with R. G. White, he found that cattle repeatedly injected with virulent blood developed isolysins in their sera. The cellular individuality of cattle thus came to light: and Todd and White showed that with suitably absorbed sera the blood cells of any individual could be distinguished from those of any other.

In 1925 Todd left Egypt, having worked on many aspects of public health and received many honours. In 1926 he was given a research grant to work at the National Institute for Medical Research at Hampstead. Here he continued his studies on cellular individuality, now using fowls, in which isohæmagglutinins were readily produced. As with cattle, he found that with absorbed sera he could pick out bloods of individual fowls. He went further and determined that the immunological specificity was inherited: polyvalent sera absorbed with cells of both parents had no action on the cells of their chicks.

At Hampstead Todd worked also on fowl plague and described a 'dilution phenomenon' in which just neutral serum–virus mixtures had their activity restored by dilution. With Perdrau he made studies of the photodynamic action of methylene blue on bacteriophage and other viruses. He finally retired in 1940.

Todd was a delightful and helpful colleague with a great zest for life and a wonderful sense of fun. He had a wide knowledge of public health and microbiology and knew not a little about physics. He delighted in 'Heath-Robinson' gadgets, had a very critical mind and scorn for pretentiousness. He was elected Fellow of the Royal Society in 1930. He was unmarried.

C. H. Andrewes

Dr. R. O. Page

With the death of Robin O. Page, which occurred on July 14 in Christchurch, New Zealand, the science of leather chemistry has suffered a heavy loss. Robin Page was born in 1897 at Christchurch, New Zealand, which was to become his residence for the rest of his life. During his college years he distinguished himself as a scholar and in various sports; he even represented his country in athletics. After receiving the master's degree with first-class honours in chemistry at University College, Canterbury, in 1920, he joined the staff of Woolston Tanneries, Ltd., Christchurch, as a chemist. He was appointed works manager in 1924—a position which he held up to his death.

At an early age he was fascinated by the intricate problems of the mechanism of tanning reactions; an interest which followed him all through his active life. To his inquiring mind the fundamentals and theoretical concepts were vital exigencies. In addition to carrying responsibility in the industry, Page not only kept himself informed about current scientific progress but also contributed a distinguished series of more than twenty original papers—the result of the research which he carried out alongside his practical duties for the love of the great unknown of his 'bread and butter' reactions.

Page was one of the first investigators to realize the importance of the physico-chemical approach in the elucidation of tanning processes, being inspired by the new ideas of the early 'twenties, propounded by Jacques Loeb and John Arthur Wilson, on the behaviour of proteins. This is shown by his lucid papers on ion effects on collagen published in 1927. The subsequent main contributions of Page concern the mechanism of the vegetable tannage. With his sound conception, thorough knowledge of chemistry and critical outlook, the tannery experience became to him a solid background for these pioneering investigations. Among his more recent publications, his clarifying investigation of the classical tannin–

gelatin reaction—first studied by Humphry Davy in 1803—should be especially mentioned for its explicity of technique and sound theorization. These papers, published in British and American journals, made Page an outstanding figure in contemporary leather research.

His scholarly endeavour was early recognized, not only by his own colleagues. Thus, the University of New Zealand conferred the degree of D.Sc. upon him in 1934. Dr. Page took an active part in the scientific life of his own country, being a Fellow of the Royal Institute of Chemistry, a Fellow of the New Zealand Institute, also a past president of that body, and a Fellow of the Royal Society of New Zealand. During overseas visits to Europe and the United States he made many friends. The man and his achievements carried the imprint of sterling qualities.

K. H. GUSTAVSON

NEWS and VIEWS

Royal Society Medal Awards

THE following awards of medals have been made by the President and the Council of the Royal Society: *Copley Medal* to Sir Howard Florey, professor of pathology in the University of Oxford, for his distinguished contributions to experimental pathology and medicine; *Davy Medal* to Dame Kathleen Lonsdale, professor of chemistry at University College, London, for her distinguished studies in the structure and growth of crystals; *Buchanan Medal* to Sir Neil Hamilton Fairley, for his distinguished contributions to the control of malaria; *Hughes Medal* to Prof. J. Proudman, professor emeritus of oceanography in the University of Liverpool, for his distinguished work on dynamical oceanography.

Royal Society of Edinburgh: Officers for 1957–58

THE following have been appointed to the Council of the Royal Society of Edinburgh for the session 1957–58: *President*, Prof. James Ritchie; *Vice-Presidents*, Prof. J. Norman Davidson, Principal H. B. Nisbet, Prof. Meirion Thomas, Prof. A. C. Aitken, Dr. J. E. Richey and Prof. D. Whitteridge; *General Secretary*, Prof. Norman Feather; *Secretaries to Ordinary Meetings*, Dr. T. R. Bolam, Dr. A. W. Greenwood; *Treasurer*, Dr. J. R. Peddie; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Councillors*, Dr. D. A. Allan, Prof. G. H. Bell, Dr. D. N. McArthur, Dr. A. G. MacGregor, Prof. C. H. Waddington, Dr. J. A. Macdonald, Dr. R. Schlapp, Dr. J. B. Tait, Prof. G. M. Wyburn, Prof. R. A. Rankin, Prof. A. E. Ritchie and Prof. W. M. Smart.

Royal Society of South Africa: Elections

THE following have recently been elected to fellowship in the Royal Society of South Africa: Dr. R. A. Alexander, director of veterinary services, South Africa, Onderstepoort, Pretoria; Dr. J. J. Frankel, Department of Geology and Mineralogy, University of Natal, Durban; Prof. I. Gordon, professor of pathology and dean of the Medical Faculty, Medical School, Durban; Prof. F. G. Holliman, professor of organic chemistry in the University of Cape Town; and Dr. R. H. Marloth, director of the Citrus and Subtropical Horticultural Research Station, Nelspruit, Transvaal.

Organic Chemistry at Glasgow: Prof. R. A. Raphael

THE appointment of Ralph Alexander Raphael to the regius chair of chemistry at Glasgow brings him back to the University where he held a lectureship during 1949–54. He graduated from the Imperial College of Science and Technology, London, in 1941, with first-class honours, and obtained the Ph.D. degree in 1943. After a period with Messrs. May and Baker, Ltd., he returned to the Imperial College in 1946 with an Imperial Chemical Industries Fellowship. His distinction as an organic chemist won early recognition when he was awarded the Meldola Medal for 1948 at the age of twenty-seven. His main interest in research has been the study of acetylenic compounds and, in particular, the use of such reagents as precursors in the synthesis of a wide range of naturally occurring organic substances. In 1954, Dr. Raphael became the first professor of organic chemistry at The Queen's University of Belfast. The combination of his skilful leadership and his enthusiastic personality led to a rapid expansion of the research school in organic chemistry during his three years at Queen's; his outstanding success there as a teacher and as a director of research augurs well for the future of organic chemistry in Glasgow.

Organic Chemistry at Belfast: Prof. H. B. Henbest

THE appointment of Dr. H. B. Henbest to the chair of organic chemistry at The Queen's University of Belfast, in succession to Prof. R. A. Raphael, certainly represents an example of a meteoric rise. Graduating with first-class honours at the Imperial College of Science and Technology, London, in 1944, he worked under Prof. (then Dr.) E. R. H. Jones, a collaboration he was enabled to continue after his doctorate by the award of a Beit Research Fellowship. Henbest accompanied Jones to Manchester on the latter's appointment to the chair in 1948, and remained there as a lecturer in organic chemistry until 1956; this was punctuated by a year's leave of absence, during which he worked at Harvard and the University of California, Los Angeles. Only shortly before the appointment to Queen's he had moved to King's College, London, as reader in organic chemistry.

The outstanding impression of Henbest's research work is its lack of triviality and its concentration on important and live topics. His first conjoint project was the establishment of an improved route to provitamin D_3, and, continuing his steroid interests, he played a large part in devising a new route to cortisone from ergosterol. Another outstanding achievement in the vitamin field was the establishment of the structure of vitamin A_2 by an unambiguous synthesis. A logical extension of interest to plant hormones led to synthetic work in relation to the postulated structure of auxins *a* and *b*, and to the isolation and proof of structure of a new plant hormone, 3-indolylacetonitrile. Aspects of acetylene chemistry have also engaged his attention, leading, for example, to the synthesis of kawain. At present he is engaged on a series of highly original stereochemical investi-

gations of a fundamental nature, which have considerable potential use in the stereoselective elaboration of organic molecules. His appointment coincides happily with the fruitful expansion of these investigations and with his new department's move to its palatial new quarters in the near future.

Royal Military College of Science, Shrivenham: Prof. A. Charlesby

Dr. Arthur Charlesby, who has been appointed professor of physics at the Royal Military College of Science, Shrivenham, is forty-one years of age, and was educated in London and at the Royal Atheneum, Antwerp, and the University of London, where he obtained a Ph.D. in 1939, and where he was afterwards engaged in research and teaching until 1942. After a period in the scientific research department at the Ministry of Aircraft Production he served with the R.A.F. until 1945, during which time he was engaged on operational research into the scientific aspects of aerial warfare in the Mediterranean. During 1949–54 he was a principal scientific officer at the Atomic Energy Research Establishment, Harwell, where he was in charge of a group studying the effects of atomic radiation on materials. He obtained a D.Sc. in 1954. For the past two years he has been head of the Radiation Department of Tube Investments Research Laboratories. He has written numerous papers on solid state and nuclear subjects and is the editor of an international series of books on the effects of atomic radiation.

Prof. A. D. S. Carter

Prof. Alfred Denis Snowdon Carter, who has been appointed professor of mechanical engineering at Shrivenham, is thirty-five years of age, and was educated at Neath Intermediate School and at the University of Wales. After short periods of research at the Royal Aircraft Establishment and with Power Jets (Research and Development), Ltd., he joined the National Gas Turbine Establishment in 1946, since when he has been working on aerodynamic and vibration problems connected with the gas turbine. He has published many papers on blade theory and performance, on the axial compressor, and on vibration problems associated with the gas turbine. Prof. Carter is a member of various Government scientific committees and an active member of the Institution of Mechanical Engineers; during 1952–55 he was a member of the Council of the Institution.

Prof. A. Lee

Prof. Alan Lee, who has been appointed professor of electrical engineering (radar and telecommunications) at Shrivenham, is fifty years of age, and was educated at Todmorden Grammar School and at Emmanuel College, Cambridge, where he read mathematics and mechanical sciences. After a short period of research in industry and teaching at the R.A.F. Electrical Wireless School, Cranwell, he joined the Royal Military College of Science in 1935. He has been head of the Radar and Telecommunications Branch since 1941. He has been a member of a number of Government committees connected with his subject.

Advisory Council

The following have been appointed to the Advisory Council of the Royal Military College of Science to replace members whose terms of office had expired: Prof. J. Diamond, of the University of Manchester; Prof. M. H. L. Pryce, of the University of Bristol; and Mr. R. P. Bell, of Balliol College, Oxford.

Laboratory of Cryptogamic Botany, University of Manchester: Mr. E. Ashby

After forty-seven years of service as chief steward and technician in the Laboratory of Cryptogamic Botany of the University of Manchester, Mr. Ernest Ashby will retire on November 25. He joined the laboratory soon after the appointment of Prof. W. H. Lang as the first occupant of the Barker chair of cryptogamic botany and continued with Prof. C. W. Wardlaw on his appointment in 1940. Over this long period, Mr. Ashby's talents for growing plants, often of a difficult and wayward nature, and for preparing materials for microscopic study, have been of great value in the research and teaching activities of the laboratory; and many have gratefully acknowledged his help. Perhaps most of all, his love of photography and photomicrography, and his zest for the achievement of perfection in them, have made a notable contribution to botanical illustration. The value of his work was recognized during the year by the conferment upon him by the University of the honorary degree of Master of Science. His many friends and associates have welcomed this signal honour and will wish him well in his retirement.

Royal Society Antarctic Expedition: Mr. Joseph MacDowall

Mr. Joseph MacDowall has been appointed leader of the Royal Society International Geophysical Year Antarctic Expedition at Royal Society Base, Halley Bay, from January 1958 until the party returns to the United Kingdom in the spring of 1959. He succeeds Col. Robin Smart, R.A.M.C., the present leader, who accepted the appointment only for the current year. Mr. MacDowall, who was seconded to the expedition from the Meteorological Office, Air Ministry, where he holds the rank of senior scientific officer, is aged thirty-one. He was educated at Wallasey Grammar School and served in the Royal Naval Air Arm during 1946–48. For the next three years he studied at St. John's College, Cambridge, and then joined the Meteorological Office, where he worked at Kew Observatory and in the Instrument Division. Mr. MacDowall went to Halley Bay in November 1956 as leader of the meteorological and geomagnetic group which has been responsible for making the surface and upper air meteorological observations at Halley Bay since the International Geophysical Year began on July 1, 1957, together with observations of the Earth's magnetism and the accumulation of ice and snow in past years.

Orbit of the Second Artificial Earth Satellite

The time of launching of the second Russian artificial Earth satellite is as yet unknown, but it was first detected in Britain with the Cambridge radio interferometer on November 3d. 05h. 58m. The satellite has been observed since then both visually and by radio methods. An orbit telegraphed to the British Astronomical Association from Copenhagen (*Brit. Astron. Assoc. Circular*, No. 391; November 8, 1957) gives equatorial elements computed by Cunningham for epoch November 4·0:

M	151°	φ	6° 02′ (e 0·105)
ω'	44	a'	1·1463
Ω'	118	Daily change in ω'	+ 0·6°
i'	62° 30′	,, ln Ω'	− 3·1

(The major axis is presumably quoted in terms of the Earth's equatorial radius.) These values are supported by elements computed by the Mullard Radio Astronomy Observatory, Cambridge, which gives a somewhat larger inclination, namely, 65°, and a period of 103m. 40s. The figures, which should be regarded as tentative since they are based on a few observations only, lead to heights at perigee of 250 km. and at apogee of 1,630 km.

The observable passages of this satellite near the British Isles occur at present between 5h. and 15h. each day, and it can be seen as a bright object (magnitude − 1 to + 1) when suitably placed before dawn. Since 14 revolutions occur in 1,451m. 5s., the tracks repeat themselves 11m. 3s. later each day, and this interval, together with the regression of the nodes, causes the tracks to swing westwards about 7° per day.

Russian Earth Satellites and the International Geophysical Year

In a written reply to a question regarding scientific information on the first Russian Earth satellite in the House of Commons on November 1, M. H. Nicholls, the Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Royal Society and not the Department of Scientific and Industrial Research is responsible for co-ordinating United Kingdom participation in the programme of the International Geophysical Year. The appropriate committee is considering the arrangements for collecting scientific information obtained in Britain from the Earth satellites and transmitting it to the World Data Centre of the International Physical Year for publication. In addition, it was understood that arrangements were in hand for an account of some British observations of the satellite to be published.

Theratron Cobalt-60 Beam Unit at Westminster Hospital

At Westminster Hospital, London, on November 4, the Lord Chancellor, the Right Hon. Viscount Kilmuir, unveiled a commemoration plaque and so put into commission a theratron cobalt-60 beam unit that is a gift to the Hospital, through the British Empire Cancer Campaign, from Mr. and Mrs. Michael Wix. This apparatus, made by Atomic Energy of Canada, Ltd., is the second theratron to be installed in Great Britain, and is designed to permit moving-beam treatment of malignant disease while the patient lies upon a couch that forms an integral part of the equipment. An additional feature of this second theratron is a facility that permits the couch to be moved to and fro simultaneously with the rotation or other movement of the beam. Also, all adjustments of the couch in order to arrange a patient precisely for treatment are electrically powered so that a single 'joy-stick' switch readily permits movement up or down or to and fro. The cobalt source behaves effectively at approximately 1,500 curies and provides, at a distance of one metre, a dose-rate of 33 röntgens per minute.

During the proceedings before the unveiling ceremony, Sir Stanford Cade gave a brief historical survey of the Hospital's Radiotherapy Department, tracing the growth of its radiotherapeutic tools from a few milligrams of radium in 1922 to a 1-gm. radium unit in 1929 and then to the present when, in addition to conventional X-ray machines, it now has a two-million volt Van de Graaff generator, the theratron put into commission on this occasion and a cæsium-137 beam unit that is now being assembled. Lord Kilmuir, in his address, emphasized that there is still a place within the National Health Service for the private benefactor who feels called upon to serve the welfare of his fellows. This gift of a theratron, which will benefit the unfortunate victims of cancer for many years to come, is a striking example of such service.

British Museum (Natural History) : The Stanwick Skull

Among the items reported to the Trustees of the British Museum at their meeting at the British Museum (Natural History) on October 26, was the gift by the Society of Antiquaries, London, of a human skull showing fatal wounds, found during excavations of the Roman fortifications at Stanwick, Yorkshire, during 1951–52. Examination of the skull showed that it was that of a man who had been violently attacked with a sword or axe, and afterwards beheaded. The slaying probably took place just before the capture of the Iron Age fortress by Roman troops in A.D. 71–74. It is uncertain whether the skull is that of a British native or of a patrolling Roman soldier. As it was found in the ditch close to the entrance of the fortress, and was not accompanied by other human bones, the head was probably displayed on the gate, and then became dislodged and fell into the ditch during the final attack. The skull is referred to by Sir Mortimer Wheeler in "The Stanwick Fortifications" (Report of the Research Committee of the Society of Antiquaries, **17**, 533; 1954).

Fertility and Fertility Control

The first Oliver Bird Lecture was delivered by Drl T. Mann at University College Hospital Medica. School, London, on November 6; he spoke on "The Biochemical Basis of Spermicidal Activity". The lecture was sponsored by the Society for the Study of Fertility and held under the auspices of the Oliver Bird Trust (see *Nature*, October 12, p. 737). Dr. Mann discussed the mechanisms of action of various compounds which render sperm incapable of fertilization, either by killing them, by inhibiting their motility, or affecting their fertilizing power without impairing their motility. The latter part of the lecture dealt with the biochemical aspects of the use of spermicides as contraceptive agents, and discussed some of the pitfalls in the way of equating spermicidal activity *in vitro* with contraceptive activity *in vivo*. The lecture was preceded by the first meeting of the Council for the Investigation of Fertility Control, which was set up by the Oliver Bird Trust to work with the Family Planning Association in the organization of tests and clinical trials of contraceptives in Great Britain and elsewhere.

Calouste Gulbenkian Foundation Grants

The Trustees of the Calouste Gulbenkian Foundation, Lisbon, have announced the Foundation's second list of grants, totalling more than £1 million. Among the grants for scientific, medical and other research (totalling £403,250) are the following: to the National Laboratory of Civil Engineering, Lisbon, up to £250,000 to build and equip a new research centre, the Calouste Gulbenkian Institute, for funda-

mental investigations in civil engineering; to Baghdad College, £50,000 towards a Gulbenkian science block for the new Jesuit university (Al-Hikma University); to the Sanatorium of Azounieh, Lebanon, £20,000 over three years for building a Calouste Gulbenkian Research Centre for Chest Diseases, to serve the Middle East, £10,000 for laboratory equipment, and £6,000 over three years towards the running expenses; to the Faculty of Medicine, University of Lisbon, £22,500 to install, equip and maintain for three years a laboratory of electron microscopy in the Institute of Histology and Embryology, and £18,500 to the Laboratory of Physiological Chemistry for essential materials and research; for a new Centre for Agricultural Economics in Portugal, £15,000 initially to establish and run the new centre as part of the Foundation's own activities; to the Sarawak Museum, British Borneo, £5,000 for the excavation during 1958 of the great cave of Niah in Subis Mountain (see *Man*, 57, 161, November 1957); to the Institute of Archæology, Faculty of Arts, University of Coimbra, £2,500 for archæological research in Iraq; to the Office of Town-Planning Research, Lisbon, £1,250 a year for three years. Other grants include Gulbenkian Fellowships, for which £15,000 has been set aside in the United Kingdom for three years to encourage co-operation between selected universities and teachers of mathematics, science and technology in nearby schools, technical colleges and training colleges, with the view of improving the quantity and quality of science teaching; and grants to undergraduate scientific expeditions from the United Kingdom, for which up to £2,600 will be granted over three years. The two expeditions assisted this year have been from the University of Cambridge to the Colombian Cordillera Oriental and to French West Africa. £2,000 has been allocated to the Mathematical Association, to finance the publication of the Association's authoritative reports and recommendations.

Indonesian Council for the Sciences

A Council has been established by Act of the Republic of Indonesia, under the name of "Madjelis Ilmu Pengetahuan Indonesia", to work in the scientific field in Indonesia. The tasks of this Council include: the promotion of science in Indonesia; advising the Government in scientific matters; encouraging the exchange of scientific information between Indonesia and the rest of the world; the direction of institutes; and the allocation of funds entrusted to it. Further information can be obtained from the Information Department of the Indonesian Council for Sciences, Medan Merdeka Selatan 11 pav., Djakarta.

Announcements

Owing to other commitments, the Rev. C. E. Raven has retired from the presidency of the Field Studies Council. The Rt. Hon. Lord Hurcomb has agreed to fill the office with effect from November 1.

The Textile Institute has made the following awards: *Institute Medal* to Mr. G. Loasby, chairman of the Council of the Institute since 1955, in recognition of distinguished services to the textile industry in general, and to the Textile Institute in particular; *Service Medal* to Mr. H. Pomfret, honorary secretary of the Blackburn Section of the Institute for eleven years; and to Dr. P. P. Townend, Department of Textile Industries, University of Leeds, a former chairman of the Yorkshire Section of the Institute.

The nineteenth annual congress of the British Institute of Radiology will be held at the Royal Horticultural Halls and the Napier Hall, Westminster, during November 27–29. Further information can be obtained from the General Secretary, British Institute of Radiology, 32 Welbeck Street, London, W.1.

A programme of scientific films in colour, organized by the Society of Chemical Industry, will be shown at the Royal Empire Society, 18 Northumberland Avenue, W.C.2, on November 18, at 6.30 p.m. The films to be shown include "Canadian Wheat" (National Film Board of Canada); "Point of New Departure" (Imperial Chemical Industries Ltd.) on synthetic fibres with emphasis on 'Terylene'; "Coral Wonderland" (Australian News and Information Bureau); and "A Vitamin Emerges" (Glaxo Laboratories Ltd.) on the story of vitamin B_{12}. The meeting is open to members of the Society, who may bring friends.

A joint symposium on "Recent Developments in Industrial Low Temperature Gas Separation", organized by the Institution of Chemical Engineers and by the Low Temperature Group of the Physical Society, is to be held at the Royal Institution, Albemarle Street, London, W.1, on November 26. The papers read at the meeting will be published, together with a report of the discussion, in the *Transactions of the Institution of Chemical Engineers*. Further details and registration forms for those wishing to attend the symposium may be obtained from the Physical Society, 1 Lowther Gardens, London, S.W.7, or from the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

The first Sherrington Memorial Lecture of the Royal Society of Medicine will be delivered by Lord Adrian at 8 p.m. on November 27 in the Barnes Hall. The subject of the Lecture will be "The Analysis of the Nervous System". Admission to the Lecture, which is open to Fellows of the Society and their guests, is by ticket, obtainable from the Royal Society of Medicine, 1 Wimpole Street, London, W.1.

Under the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and British Colonies to go to the United States for an academic or educational purpose, provided that they have the financial support in dollars for the visit, and have been accepted by an American institution of higher learning. The grants cover the cost of direct travel between the candidate's home and the United States and return, and are available during June 1, 1958–April 1, 1959. Applications must be submitted by March 15, 1958 (for those travelling between June 1 and August 15, 1958) or by June 1 (for those travelling after August 16). Application forms and further information can be obtained from the United States Educational Commission in the United Kingdom, 71 South Audley Street, London, W.1.

Erratum. In the article on the orbit of the first Russian Earth satellite in *Nature* of November 9, there is an error in the time of transit given in the last line of Table 1 on p. 938: for "05 hr. 29 min. 22 sec." read "05 hr. 28 min. 30 sec.".

RADIOISOTOPES IN SCIENTIFIC RESEARCH

UNESCO CONFERENCE

AN International Conference on Radioisotopes in Scientific Research arranged by Unesco was held in Paris during September 9–20. Some 1,200 scientists from sixty-one countries assembled in the Faculty of Medicine. This was the largest conference on isotopes ever held, and was very considerably bigger than the previous Isotope Conferences at Oxford in 1951 and 1954.

The impressive opening of the Conference took place at the nearby Sorbonne, where the president, Sir John Cockcroft, gave a short speech in which he stressed the importance of isotopes and said that, "What has been established already has shown the importance of radioisotope techniques in such wide and diverse fields that they rival nuclear power itself for their benefits to humanity". After the opening, except for two plenary sessions, all meetings were divided between the physical and biological sciences.

Physical Sciences Sessions

More than a hundred papers were read and discussed. They gave an astounding mass of information and showed the great progress which has been made since the last Geneva Conference two years ago.

In the sessions on production of isotopes, a paper was discussed dealing with the long-lived radioisotope aluminium-26, and its properties; a Russian paper dealt with new methods of depositing alpha-, beta-, and gamma-sources; French and British papers gave details of the extraction of the fission product cæsium-137, an isotope which will be used in the future for irradiation sources.

The session on the physics of metals dealt with diffusion problems, metal structure and grain-boundary diffusion. Radioisotopes have shown themselves to be the outstanding tool for development in this field. Research in industrial applications was represented by a theoretical paper on the measurement of fluid density, and by another in which outstanding results on flotation studies were presented.

Solid-state physics and physical chemistry in general were represented by many papers. Perhaps the most interesting were those describing research on structural defects in germanium monocrystals and the elegant emanation method used to give insight into the uranium oxide–zinc oxide and uranium oxide–titanium oxide systems. A number of papers dealt with exchange reactions of ions and complexes, and determination of the heat of sublimation and the diffusion of aqueous vapour. Radioactive gases were used for solid-surface measurements.

A number of interesting papers dealt with organic chemistry. One Russian paper threw new light on the mechanism of catalysis and a German paper dealt with the study of the Hoffmann degradation using tritium. An interesting session dealt with recoil chemistry; and the more general applications of Szilard–Chalmers reactions were described. A most interesting report was by Wolf (United States) on the use of recoiling carbon-14 in a new technique for labelling organic compounds. This technique recently developed may have big future applications in organic synthesis of carbon-14 compounds. Another American paper dealt with the recoil of tritium atoms on organic compounds, a process which also seems to have good preparative prospects.

In analytical chemistry emphasis was on gamma-ray spectrometry, a development which seems to have gone so far that in certain circumstances it can be relied upon entirely to the exclusion of chemical separations.

Two plenary sessions dealt with methods and techniques. A number of papers described progress in scintillation counting and counting methods. Two interesting British contributions were on the measurement of chromatograms, and on a technique for the simultaneous recording of the instantaneous counting rates of phosphorus-32 and iodine-131 in blood. An amusing application dealt with the use of oxygen-15, which has a half-life of 2·1 minutes, in relation to the tension in neoplasms. A number of papers dealt with improved methods of autoradiography, including a Russian contribution on an autoradiographical technique in which high pressure is applied to radioactive leaves which are between layers of filter paper.

Of outstanding interest were the two sessions on geophysics. The Japanese have studied antique relics by back-scattering methods. The sulphur-32–sulphur-34 ratio in meteorites has been investigated as well as the radioactivity induced by cosmic rays in meteorites and tektites. Dr. Libby read a paper which drew conclusions about the continental water-balance by measuring man-made tritium resulting from atomic bombs. This calculation, which was based on a number of assumptions, was nevertheless interesting in so far as it was possible for the first time to make any estimate at all of the continental water reservoir, especially in the Mississippi valley. It also gave estimates of the general rates of turnover of water.

The last day was devoted to isotope research in connexion with parity in physics, and a number of specialists, including Miss C. S. Wu, Dr. M. Deutsch and Dr. H. Halban, spoke on this problem.

A number of interesting films, including some from the United States, the U.S.S.R., Britain and France, were shown during the lunch intervals. They dealt with atomic reactors, isotope production and applications. Two private symposia were held, on the production of isotopes and on residual radioactivity in finished products. They were of great benefit as they allowed a free exchange of international opinion around a small conference table.

All the sessions on physics and chemistry had a very numerous and interested audience; this shows that chemists and physicists at least are not yet so specialized that they cannot follow scientific subjects other than their own with interest. It is to be hoped that such conferences will be repeated at two or three yearly intervals, for while they give an opportunity for people working in similar fields to meet, at the same time they may help to counteract the threat of over-specialization among scientists.

H. SELIGMAN

Biological Sciences Sessions

The Biological Sciences Sessions at the Unesco Conference on Radioisotopes in Scientific Research were planned on an ambitious scale to embrace all major fields of biological study in which isotopes are used, excepting only clinical diagnosis and the biological effects of radiation. More than a hundred papers were read at seventeen sessions embracing pharmacology; thyroid metabolism; lipid metabolism, blood and blood proteins; nucleic acids; protein and amino-acid metabolism; metabolism in brain and nervous system; carbohydrate metabolism; metabolism of fission products in soils, plants and mammals; nutrient assimilation in plants; translocation in plants; photosynthesis; plant biosynthesis; plant metabolism; and productivity of oceans and lakes. In addition, plenary sessions attended by both physical scientists and biologists were devoted to questions of technique, and a number of evening lectures of a more general nature were provided. Speakers from eighteen countries appeared on the programme. France, the host country, was the major contributor, but Belgium, the United Kingdom, the United States and the U.S.S.R. each provided ten or more papers. Other contributors came from Canada, Denmark, Germany, Ghana, India, Israel, Italy, Japan, the Netherlands, Poland, Roumania, Sweden and Yugoslavia.

The preparation of this programme was clearly a considerable task for the small panel of scientific consultants. Only a limited time was available for organizing the Conference, and it was necessary for them to consider not only the scientific quality of contributions but also the adequacy of the coverage of the subjects chosen, and the appropriate representation of different countries.

In terms of breadth of scope and international participation, Unesco achieved its objective. However, these requirements are difficult to reconcile with a uniformly high standard of scientific presentation. Moreover, the serious exchange of scientific ideas is easier when the subject of a conference is narrower and the interests of its participants are correspondingly closer. In the present Conference a further difficulty in the biological sessions was that, even at the best-attended lectures, the audience was lost in the spacious, it may be said magnificent, surroundings of the Grand Amphitheatre of the new Faculty of Medicine of the University of Paris. It is natural, therefore, that much of the most useful scientific discussion occurred in private. None the less, some sessions gave rise to most interesting discussions on the floor of the hall.

Abstracts of all papers presented have already been published (*International Journal of Applied Radiation and Isotopes*, 2, 175–264; 1957) and the Proceedings of the Conference are now in preparation; a detailed review is therefore inappropriate here and reference will be confined to general aspects.

A discussion in the session on lipid metabolism illustrated clearly the advantage which can occur when workers from widely differing fields are brought together. In a paper reporting work on lipids in the blood and milk of cows, reference was made to an as yet unidentified component in blood which had aroused interest by virtue of the high specific activity it rapidly attained in tracer studies. During subsequent discussion the possibility emerged that this component might well be diglycerophosphate, which had lately proved to be an important, though hitherto unidentified, metabolic intermediate in algæ. It was most unfortunate that the division of the programme into 'animal' and 'plant' sessions caused the presentation of the paper on lipid synthesis in algæ which dealt with this question to be deferred to a later session. Such examples of biochemical studies in plants providing interpretations of results obtained in animals are rare; new concepts developed in investigations with animals have more frequently aided the elucidation of biochemical problems arising in connexion with plants.

To many British and American representatives at the Conference the presence of a strong delegation from the U.S.S.R. was of particular interest. Russian contributions occupied the greater part of the session on the metabolism of the brain and the nervous system; the turnover of proteins and nucleoproteins, and the metabolism of glycogen were here major questions of interest. Russian contributions were also numerous in the session on plant biochemistry and photosynthesis.

One session was devoted to the metabolism of fission products in soils, plants and mammals. The major focus of interest was the relative behaviour of strontium and calcium throughout the biosphere. This question was discussed in relation both to the upward passage of the two ions from the roots to the shoots of plants and to their subsequent metabolism in the animal body. The extent to which strontium, and also iodine, are transferred to milk was also discussed.

A day was devoted to the assimilation and translocation of nutrients in plants. In contrast with contributions at many earlier conferences on the application of tracer methods to this field, the majority of the papers were concerned with detailed physiological questions, such as the factors controlling translocation and the nature of the flux of ions across the cytoplasm of cells. Large-scale field experiments with labelled fertilizers, which were at one time widely believed to hold considerable promise, received little consideration.

In several evening lectures the importance of the industrial applications of radioisotopes was emphasized. Spectacular achievements were reported in the reduction of production costs by the use of radioactive thickness gauges and other procedures. It was estimated that in the United States industry is already saving more than 300 million dollars a year. Agriculture, the world's greatest 'biological' industry, promises no comparable rapid economic gain. The opportunity, which radiation provides, of producing new varieties of plants by mutation was referred to on a number of occasions. However, the probable value of this procedure can easily be overrated. As a representative of the Food and Agriculture Organization of the United Nations stated: "One word of warning, however, is needed in this connexion. It should be remembered that few countries, developed or underdeveloped, have adequately exploited, in their plant breeding programmes, the breeding material already present in their native crops or in material that could easily be introduced from other parts of the world. It is important, therefore, especially in countries with a limited number of scientists, that plans for the use of radiation in plant breeding should not be at the expense of money and trained manpower needed for

the basic fundamentals of an effective plant breeding programme conducted on a conventional basis." However, if the Conference held out no prospects of isotope procedures leading to immediate economic gain in the biological sphere comparable to that which may result from their application to the physical processes of industry, there was ample evidence that the eventual gain through research applied both to medical and agricultural questions may be at least as great.

This Conference may in some ways be regarded as the successor, though on a larger scale, to other isotope conferences, for example, those which the United Kingdom Atomic Energy Authority held at Oxford in 1951 and 1954. Apart from the lavish hospitality which the French Government and several embassies provided, the most striking aspect in which the Paris Conference differed from its predecessors was in a shift of emphasis from techniques to results. It is true that the sessions devoted to techniques were of considerable interest, particularly from the point of view of scintillation counting, very rapid sampling procedures in biological work, and autoradiograph procedures. Much information on these questions is, however, now readily available, and facilities for tracer work have become as much part of the normal equipment of many biological laboratories as the microscope. Past conferences on radioisotopes in research have greatly aided this development and the value of the Paris Conference is beyond doubt. However, it can legitimately be asked whether such gatherings have, by their success, made their continuation largely unnecessary for the experimental biologist. The majority of scientific conferences concerned with experimental biology to-day embrace some aspects of radioisotope research; in the future it will be increasingly so, and the successful use of tracer methods may in future be better stimulated by conferences convened to discuss more limited fields.

R. Scott Russell

STATISTICS IN THE UNIVERSITY OF ABERDEEN

THE University of Aberdeen was among the first of British universities to provide for the teaching of statistics: in 1906, the Senatus recommended "the institution of a short course of lectures in the University on Statistical Methods which, in the opinion of the Senatus, is required for the equipment of advanced students in various branches of Science". In consequence of this recommendation, Mr. W. R. Macdonnell was "asked to act as lecturer, as he has given much attention to the subject and is competent to impart instruction in it". Macdonnell, who had been closely associated with Prof. Karl Pearson of University College, London, laid a firm foundation on which his successor, Dr. J. F. Tocher, was able to build more ambitiously. Tocher was one of the pioneers in the teaching of statistical methods and in the practice of statistical science; a well-known Aberdeen personality, about whom anecdotes are still current, he was lecturer during 1910–39. The University Calendar for 1920 shows that, even at this early date, Tocher was providing, single-handed, a breadth of statistical instruction that would not shame any university to-day: his lectures ranged over biometry, anthropometry, medical and vital statistics, eugenics and economic statistics, with strong emphasis on computing and practical work.

In 1954, the appointment of Dr. D. J. Finney as reader in statistics and the simultaneous establishment, within the Department, of the Agricultural Research Council's Unit of Statistics began a new phase of development. The resultant rapid increase in staff caused a degree of overcrowding that seriously impeded work. This period of discomfort has now ended: on October 7 Lord Cameron, chairman of the Carnegie Trust, inaugurated the new building that the Department now occupies. The building is a four-floor extension to the Chemistry Building in Old Aberdeen, Messrs. Pite, Son and Fairweather being the architects for both. The total cost, £32,000, has been met by generous assistance from the Carnegie Trust and the University Grants Committee and a deeply appreciated gift of £10,000 from the Rockefeller Foundation.

At present, the Department of Statistics has two floors of this building, giving an area of nearly five thousand square feet. There are individual rooms for each member of the teaching and research staff, two large rooms for a team of ten or twelve computers, two rooms for graduate students, and a classroom that accommodates up to twenty-four for practical work or more for lectures. The Department does not yet possess any large-scale computing machinery, but a room has been set aside for the eventual acquisition of electronic equipment. The accommodation must compare very favourably with that of any other university department of statistics in Britain.

The Department now has four lecturers and assistants, and the Unit of Statistics a further five graduate statisticians. A broad programme of elementary lectures enables undergraduate students in many different fields to obtain some knowledge of statistical principles; a particular feature of Aberdeen practice is the inclusion of about twenty hours of instruction in statistical science for medical students. Students of mathematics or economics can take statistics as a special subject for final honours. Aberdeen has followed several other British universities in instituting a diploma in statistics, based on postgraduate instruction, as a measure to combat the acute shortage of trained statisticians that most countries have experienced since 1945; teaching of the first students, a group of three from as far apart as Pakistan, South Africa and Wales, has just begun. In addition, there are facilities for Ph.D. students and, of particular value for those from overseas, a few students can be taken who have no degree or diploma in view but who wish to attend lectures and to gain experience of special types of statistical work.

For many years, the connexion of the Department with agricultural research has been close. The statistical sections of the Rowett Research Institute and the Macaulay Institute for Soil Research began as offshoots from the University Department; the North of Scotland College of Agriculture, situated in Aberdeen and closely associated with the University Department of Agriculture, has frequently sought assistance in the planning of field experiments and in the analysis of results. The new Unit of Statistics is intended to make a similar service available to agricultural research throughout Scotland. The aim is that any member of the staff of an agricultural

college or research institute should be able to ask the Unit for statistical advice and even for computational help where special circumstances justify this. Not least important is the possibility that, through the provision of a unified statistical analysis, the Unit can encourage co-ordination of research and of reporting on related topics studied at different centres. At the suggestion of the Scottish Agricultural Improvement Council, the Unit has recently played a leading part in initiating a Survey of Fertilizer Practice in Scotland; this Survey, performed in collaboration with the three Agricultural Colleges and following closely a pattern that has been used with success in England and Wales, for the first time gives objective information on the types, quantities and methods of fertilizer application now used by Scottish farmers.

There is no rigid distinction between the staffs of the Department and the Unit. Members of the Unit undertake some teaching and members of the University staff may help with agricultural problems; the Department gives assistance to the science departments of the University in much the same way as the Unit does to other institutes. Inevitably, there is an agricultural bias in the teaching, and, of eleven graduate students who have worked in the Department since 1954, six have been on leave from employment in agricultural research. Efforts are now being made to strengthen activities of the Department in other fields, notably in mathematical statistics and in applications to research in medicine and social science. The staff of the Department is young, and most of its members have still to make their marks in research. Nevertheless, a number of very diverse topics in pure and applied statistics are at present under investigation. Among these are problems of vital statistics and population age structure, genetic equilibrium, statistical selection, demand curves and budget analysis, queue theory, comparison and calibration of milk testing techniques, design and analysis of animal feeding trials, and special aspects of experimental planning.

BUILDING RESEARCH, 1956*

THIS publication comprises the reports for the year 1956 of the Building Research Board and the Director of Building Research, Department of Scientific and Industrial Research. In its report the Board directs attention to the very great effort devoted by the Building Research Station to securing the application of the results of research in the building industry, but comments that this work, valuable though it is, cannot be extended at the expense of the longer term and more basic investigations in the Station's programme. The Board also notes with regret the further postponement of the construction of a new materials laboratory, originally planned for completion in 1951. This delay is particularly unfortunate if, as might be expected, lack of suitable accommodation is a further factor hampering the development of the more fundamental scientific work of the Station.

The Director's report outlines the very extensive and varied programme of research work in progress during the year under review; the topics investigated range from the hydration of cement to the design of a spray tap for ablution in offices. Without losing sight of the value of those topics of more immediate practical import, a few points of particular scientific interest may be mentioned.

For the study of the constitution of the principal chemical compounds produced at high temperatures in the manufacture of cements a microscope has been developed which permits the direct examination of the material at temperatures up to about 2,000° C. The specimen is held under the microscope at the tip of a thermocouple which when heated electrically also serves to fuse the material. The different compounds present can be identified and their melting range determined by direct observation. The instrument developed at the Building Research Station represents an advance on earlier apparatus of this kind because the method of fusing the specimen and the simplicity of its construction afford a degree of flexibility and accuracy not previously attained. The instrument has also been used at temperatures above 2,000° C. for the study of the system $2\,CaO.SiO_2$–$3\,CaO.P_2O_5$, which is of interest because of the adverse effect of phosphorus pentoxide on cement quality. Other studies in the field of cement chemistry have been concerned with the lime–alumina–water system by X-ray analysis and with the deterioration of high alumina cement which has attained a high temperature during setting or which has been afterwards stored under warm, moist conditions. The deterioration has been ascribed to the conversion of hydrated mono- or di-calcium aluminates to the tri-calcium compound with release of hydrated alumina. A number of interesting photographs demonstrate the disintegration of mortar cubes, in which the conversion had taken place, when immersed for 14 days in a solution of magnesium sulphate; this resulted from the reaction of the compound $3CaO.Al_2O_3.6H_2O$, formed during the 'conversion', with the sulphate ions to produce ettringite, $3CaO.Al_2O_3.3CaSO_4.32H_2O$. Normal high-alumina cement was unaffected by magnesium sulphate solution after immersion for as long as eighteen months.

An elusive problem is the assessment of the liability of building stones to deterioration on exposure to atmospheric conditions, but some progress is reported as a result of a further study of the pore structure in which the 'suction' of the material is correlated with its percentage saturation. Curves obtained by plotting suction against moisture content are indicative of the pore structure and enable differences in structure, which may or may not be appreciable under the microscope, to be expressed in quantitative terms. It is hoped that this work will make it possible to relate the pore-size distribution to the weathering properties of bricks and stone.

Rheological studies at the Building Research Station have been concerned with lime pastes, and a viscometer of the Couette type has been employed in this work. The difficulty resulting from the thixotropic nature of the materials under test is referred to, but in spite of this, reasonably consistent results appear to have been obtained with this apparatus.

An interesting application of centimetric electromagnetic radiation is described. This is a method for the determination of the total water content between the two faces of a wall. A narrow beam of 10 cm. radiation is directed normally through the wall, and

* Department of Scientific and Industrial Research. Building Research 1956: The Report of the Building Research Board with the Report of the Director of Building Research. Pp. vi+72+19 plates. (London: H.M. Stationery Office, 1957.) 5s. 6d. net.

for a variety of materials an approximately linear relationship is found to exist between the moisture content and the attenuation of the beam.

The provision of concrete shields for nuclear reactors presents a new and complex problem in the field of materials and structures which is being studied by the Building Research Station in collaboration with the U.K. Atomic Energy Authority. Instruments are being installed in the shield of the fourth reactor now under construction at Calder Hall for the measurement of strain, temperature, joint displacement and moisture. It is expected that the observations obtained will provide valuable data for future designs.

In the field of lighting, fundamental work is in progress in collaboration with the Medical Research Council on the problems of visual fatigue, attention and adaptation.

DULWICH COLLEGE

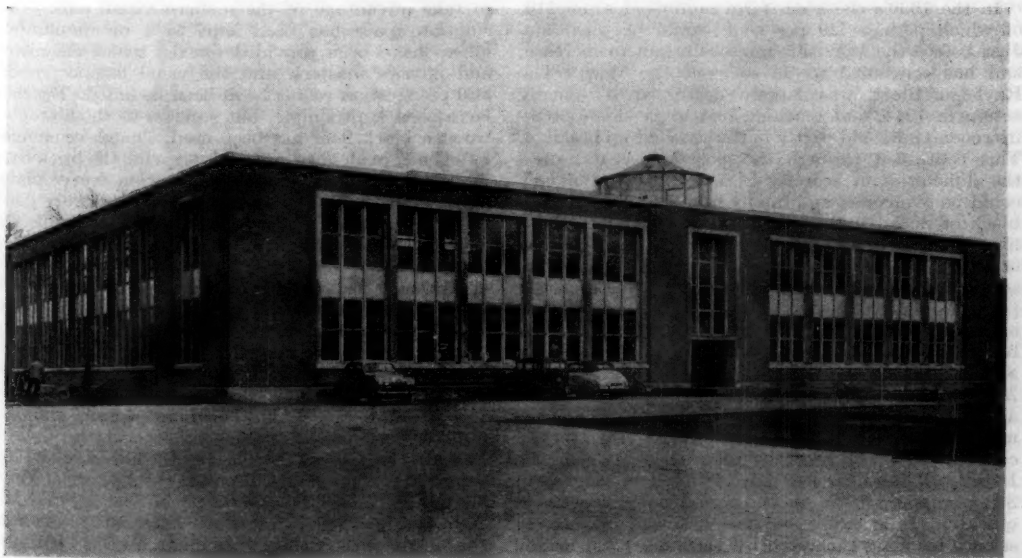
EXTENSION TO THE LABORATORIES

By R. GROVES

Master of the College

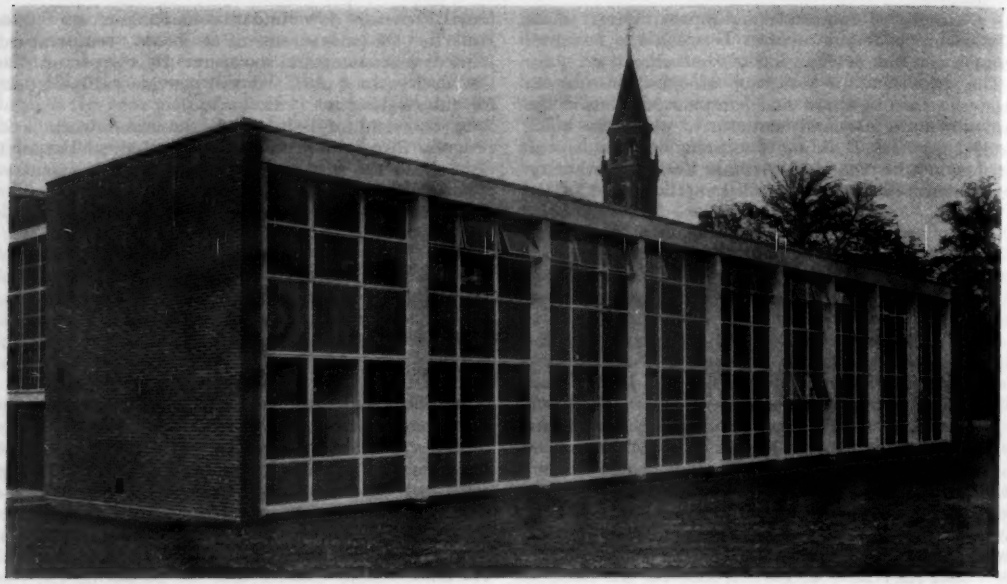
THERE can be few people now who are not convinced that the British public schools are aware of the country's need of scientific man-power. Not only is the teaching of science in these schools thoroughly 'respectable' now, but also the numbers specializing in science in the sixth forms are often more than 50 per cent of the total numbers in those forms, which is a sign that these schools realize the part that they have to play in meeting the need for scientists. The task now is to give every boy his chance to train as a scientist if he wishes, and this is more onerous than it was, for it means providing not only courses for the pure scientists, but also for those who will become technologists. It must be realized, too, that for every pure scientist we need many technologists, and for every technologist we need an army of technicians: all these have to be trained. Moreover, the sixth forms contain the classics, modern linguists and historians who, though perhaps numerically less, are still happily very strong, and it is to be hoped that they will continue to be so. It is surely essential, however, that an arts boy going up to the university must have some basic grounding in science, for he is going out eventually into a scientific world. Rather than being satisfied with a vague superficial approach to the subject, we have decided that every arts boy at Dulwich College shall do at least one physical science subject at General Certificate of Education Ordinary Level before going on to specialize in his own subject, thus attempting to give both depth and some idea of scientific method. All these considerations have led us during the past two years to do some hard thinking about the pattern of our scientific teaching, and have inevitably demanded more laboratories.

Perhaps the problem is more acute at Dulwich College, London, in that it is one of the few independent public schools which of its own volition takes a large proportion of its entrants from local authority scholars. This highly competitive entry gives it not only a remarkable cross-section of the population but also some able, fast-moving 'streams' from which many boys will go on to a university to read science or to an advanced technological institution to study applied science of some kind.



[*Copyright: May and Baker*

Fig. 1. The Dulwich College Science Block opened in 1952



[*Photo: T. H. Everitt and Son*

Fig. 2. New extension at the back of the Science Block opened on October 4

Historically, the development of this problem is interesting. Science at Dulwich was taught in the early part of the century by H. B. Baker under very primitive conditions, though much of his work on the drying of gases was done here. In 1907 Lord Rayleigh opened a new science block. At that time this must have been one of the best school science buildings in Britain, and even up to the Second World War it compared favourably with many others. It housed chemistry, physics and engineering, for which latter there was a well-equipped wood- and metal-work shop; biology was accommodated separately.

In the 1930's the sixth form numbered some 210, of which perhaps 20 per cent would be scientists. Just before the War this number began to increase, and has continued to do so since the War. The Rayleigh Block was largely destroyed by enemy action in 1944, and teaching had to be done partly in wooden huts and partly in the patched-up building. This continued through the post-war years, until the difficulties of scarcity of materials and money could be overcome, and finally in 1952 a new science block of nine laboratories, two lecture rooms and a library was opened (Fig. 1). This had been planned in 1947 when already some sixty boys were reading science for the General Certificate of Education (Advanced Level); but within a few years of its opening the number had increased to about two hundred; that is, those specializing in science after School Certificate, with one hundred taking the Advanced Level in any one year. This strained the accommodation considerably. The national call for more scientists, the demand within the school, coupled with the generous offer of help from the Industrial Fund for the Advancement of Science in Schools, spurred us on to extend—and to extend quickly. It is expected that with the increase in science teaching generally, by 1960 there will be 250 boys in the school specializing in science after reaching the Ordinary Level of the General Certificate of Education, and for these numbers we had to build our new extension.

This extension, though linked on to the previous block as the fourth long side to complete a quadrangle, has been built independently so as not to interfere with the working of the original laboratories. It gives five new laboratories, two for advanced and one for elementary chemistry, an advanced physics laboratory with ancillary electrical and dark rooms, together with a junior physics laboratory and a much-needed laboratory workshop. We also have two large lecture rooms which can become one, and thereby accommodate more than two hundred people to take advantage of the modern visual aids. Circulation space has been kept to a minimum, but offices have been provided for the senior chemistry and physics masters, and the usual balance rooms and preparation rooms have been included. Benches have been kept simple, but services to them ample; wooden block floor has been used, though economies have been made everywhere by leaving the brick bare in corridors and keeping decoration very plain. Sixth-form laboratories in particular have very good fume cupboards for chemistry, spaces available for leaving up apparatus when boys are attempting problems of a research nature, and the possibility of research to some extent, both by boys and masters, has been borne in mind in the whole plan.

The project was approved in July 1956, building was started almost immediately, the finished extension was ready for occupation in September 1957, and was officially opened on October 4 (Fig. 2). For this occasion the chairman, Lord Gorell, and the College governors entertained guests at the College Picture Gallery, at which Sir Harold Hartley, on behalf of the governors, thanked the Industrial Fund for the Advancement of Science in Schools, and Mr. John Oriel replied. In the new extension afterwards the Master of the College introduced Sir Cyril Hinshelwood, president of the Royal Society, who addressed the boys and declared the building officially open.

TIME-CORRELATED PHOTONS

By G. A. REBKA, JUN.,* and PROF. R. V. POUND
Lyman Laboratory of Physics, Harvard University, Cambridge, Massachusetts

SEVERAL studies of the time correlation of photons in coherent light beams have recently been reported in this journal[1-8]. We have undertaken to demonstrate such correlation using pulse and coincidence techniques in contrast to the continuous-wave technique used by Brown and Twiss in their first study. Our experiment differs from their more recent one[9] in that counts from each detector are recorded. These are used for reducing each observation to a measurement of effective resolving time.

Following the formulation of Purcell[4], the number of coincidences N_c in the counting period T can be written

$$N_c=(N_1N_2/T)\{2\tau_R+np\alpha\tau_0 f(\Delta)\}$$

The quantities N_1 and N_2 are the counts recorded from each detector, τ_R is the resolving time of the coincidence circuit, while τ_0 is the correlation time of the light and is related to the width and shape of the spectral line used, in the manner discussed by Purcell. The factor n accounts for the presence of pulses of other origin than the light beam, which are assumed random. In our experiment a typical value of n was 0·951. Similarly p accounts for polarization of the light beam. It would have a value of $\frac{1}{2}$ for completely unpolarized light, and had a value of 0·45 in our optical system. The degree of geometrical coherence resulting from the arrangement of the optical system is described by α, which has a maximum value of 1 for complete coherence. With the assumption of uniform sensitivity over the small photocathode areas used, a value of 0·55 was calculated for our optical system. Finally, $f(\Delta)$, where the time Δ is the difference in delay between the two channels, depends, in our limit where $2\tau_R \gg \tau_0$, mainly on the properties of the coincidence circuit and detectors. These are such that $f(0)\approx 1$, and $f(|\Delta|>\tau_R)\approx 0$. Were it possible to achieve a system with $2\tau_R \ll \tau_0$, $f(\Delta)$ would represent the square of the cosine transform of the line shape of the light source.

Fig. 1 shows the arrangement of the optical system. A modified Baird–Atomic mercury-198 electrodeless discharge tube was driven by a 10-cm.-wave-length, continuous-wave magnetron delivering about 35 watts. Vapour from boiling nitrogen provided a coolant to prevent 'clean-up' of the mercury and to prevent broadening of the line in excess of Doppler effect[10]. Considerations of line width, intensity, and detector sensitivity led us to use the 4358-A. line, which was separated with a Baird–Atomic interference filter. A phase-coherent beam was selected from the light passing through the hole, of diameter 0·02 cm., in B_1 by the hole of diameter 0·84 cm. in B_2. The baffle B_2 was 376 cm. distant from B_1. The baffle B_0 reduced reflexion from the walls housing the optical system. The dielectric mirror split the light into two beams, each of which was incident on the photocathode of an R.C.A. 6810 photomultiplier tube. Definition of the beam prior to the mirror in our system, in contrast to that of

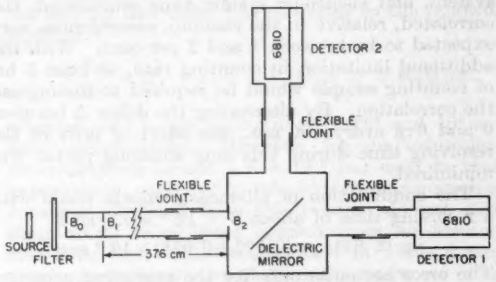


Fig. 1. A representation of the optical system. Baffles B_1 and B_2 define the geometrical coherence

Brown and Twiss[1,9], assures geometrical coherence at the two detectors without critical adjustment. Consequently we were not able to vary the correlation by changing the geometrical coherence.

The photomultiplier tubes were cooled throughout the experiment with solid carbon dioxide, and electrostatic shields at cathode potential were used to minimize dark current. The tubes were operated with an anode–cathode potential of 2,450 volts, and with the focusing grid and first dynode both 450 volts above the photocathode. Single photoelectrons produced an average pulse at the last dynode of 1/3 m.amp. and 15×10^{-9} sec. duration. Continuous application of the high voltage brought the dark current down after several days from an initially higher value to a steady state value equivalent to about 750 photoelectrons per second.

A block diagram of our electronic system is shown in Fig. 2. It represents a modification of the fast–slow system often used in coincidence spectrometry[11] in that the slow pulse-height-selecting channels were applied to the limited fast-channel pulses. Limitation of the counting speed set by the scalers and discriminators in the slow singles-channels made necessary paralysis of the limiter for a period of 4×10^{-6} sec. to eliminate coincidences between counts not resolvable in the slow channels. This resulted in a 25 per cent loss in the singles-channels for a typical counting rate of 4×10^4 counts per second. The minimum resolving time, which was limited by transit-time effects in the photomultipliers, was established by replacing B_2 by a light-pulse source composed of liquid scintillator and cobalt-60. The

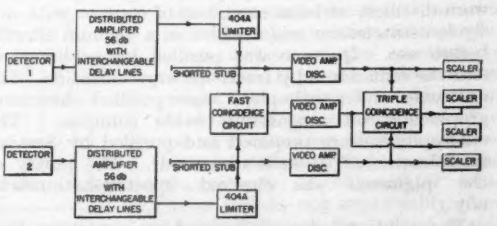


Fig. 2. Block diagram of the electronic system

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intensity of each light pulse was such that few events detected from each photomultiplier corresponded to more than one photoelectron. With this source, a curve of coincidence counts versus time-delay difference indicated a coincidence efficiency corresponding to $f(0) \geqslant 0{\cdot}85$ for $\tau_R \geqslant 6 \times 10^{-9}$ sec.

With the parameters of the light source, optical system, and electronic system thus established, the correlated, relative to the random, coincidences were expected to be between 1 and 2 per cent. With the additional limitation in counting rate, at least 5 hr. of counting sample would be required to distinguish the correlation. By alternating the delay Δ between 0 and $6\tau_R$ every 100 sec., the effect of drift of the resolving time during this long counting period was minimized.

The combination of all measurements made with a resolving time of about 6×10^{-9} sec. yields

$$np \propto f(0)\tau_0 = (0{\cdot}173 \pm 0{\cdot}018) \times 10^{-9} \text{ sec.}$$

The error accounts only for the statistical accuracy of the sample. The experimental value of

$$\tau_0 = (0{\cdot}81 \pm 0{\cdot}16) \times 10^{-9} \text{ sec.}$$

is less accurately known since measurements and estimates of the other factors contribute to the uncertainty. For a line having a Doppler-broadened shape, this value of τ_0 would correspond to a full width at half height of 820 ± 160 Mc./s. The corresponding width for a mercury source at 300° K. would be 600 Mc./s.

Other measurements were made with a resolving time of about 9×10^{-9} sec., and these gave:

$$np \propto f(0)\tau_0 = (0{\cdot}214 \pm 0{\cdot}033) \times 10^{-9} \text{ sec.}$$

and

$$\tau_0 = (0{\cdot}90 \pm 0{\cdot}22) \times 10^{-9} \text{ sec.}$$

This result indicates that our estimates of the coincidence efficiency for $\tau_R = 6 \times 10^{-9}$ sec. are not significantly in error.

A check for any systematic error inherent in changing the delay was made by repeating the measurement with the light source replaced by a direct-current mercury arc which had a broad line. No significant effect was found within the statistical accuracy of the sample.

The authors wish to thank Prof. Francis Bitter, Mr. Adrian C. Melissinos, and the staff of the Research Laboratory of Electronics, Massachusetts Institute of Technology for the loan of their specially designed mercury-198 isotope lamp.

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INTERACTIONS OF CHLOROPHYLL IN ITS TRIPLET STATE WITH OXYGEN, CAROTENE, ETC.

By Dr. E. FUJIMORI and Prof. ROBERT LIVINGSTON
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KINETIC and spectroscopic evidence[1,2] shows that the triplet (or possibly some other long-lived, energetic) state of chlorophyll is an essential intermediate in reactions sensitized by chlorophyll *in vitro*. It has been suggested[3] that the same state is involved in the photosynthesis of green plants. As a test of postulated mechanisms of the sensitized reactions, we have measured directly the half-life of the triplet state of chlorophyll, in organic solvents at ambient temperatures, in the presence and in the absence of oxygen, quinone, carotene, reductants, etc.

The solvents were of analytical reagent grade and were distilled, at least once, out of contact with air. Cyclo-octatetraene was distilled in a vacuum shortly before use. Quinone was purified by sublimation, and the reductants by fractional crystallization. The carotenes and xanthophyll were purified chromatographically on magnesium oxide columns. The chlorophylls were prepared and purified by Strain's modification of Zscheile's method[4]. The purity of the pigments was checked spectrophotometrically.

The solutions were de-aerated on a vacuum line. The stock of solvent was freed from dissolved gases by boiling off a substantial fraction at low temperature. The required sample of solvent was then transferred to the cuvette by low-temperature vacuum distillation. Known quantities of oxygen were sealed in capillaries which were placed in a side tube attached to the cuvette. After filling and re-evacuating the cuvette, the capillaries were broken and their content mixed with the solution.

The kinetic measurements were made with a flash-photolytic apparatus, provided with a single flash lamp and a scanning beam of constant intensity[5]. The scanning beam was rendered approximately monochromatic by means of one or more interference filters. After passing through the cuvette and filter, the beam fell on the sensitive surface of an R.C.A. 931*A* photomultiplier. The output of the multiplier was suitably amplified and fed to the *Y*-plates of a Techtronics 531 oscilloscope. The lamp was of 'Pyrex', 15 cm. long and filled with krypton at about 1 atm. The half-duration of the flash was approximately 10 μsec. The sweep of the oscilloscope was triggered when the lamp was fired. The resulting transient trace of the oscilloscope was recorded photographically. The sweep of the oscilloscope was linear within the limits of precision of the measure-

Table 1. Half-lives of the Triplet State of Chlorophyll *a* in Benzene containing Quinone

[Quinone] (*m.* × 10^3)	$\tau_{1/2}$ (sec. × 10^4)	$\tau_{1/2}^{-1}$ (sec.$^{-1}$ × 10^{-3})
0	4·05	2·47
2·5	3·00	3·33
5·0	2·67	3·75
7·5	1·65	6·06
15·0	1·58	6·33

ments. The times of sweep were checked with a high-frequency generator which had been calibrated with a standard crystal oscillator. The vertical displacement of the trace was proportional to the change in intensity of the light falling on the photomultiplier, within ± 3 per cent.

For transparent quenching reagents, a scanning beam having its maximum intensity at λ4775 A. was used. For quinone, the carotenes, etc., a scanning beam of λ5245 or 5720 A. was employed and the flash lamp was surrounded with an orange filter. This eliminated light which otherwise would have been, in part, absorbed by the quencher. The observed half-life for unquenched solutions was independent of the wave-length of the scanning beam. In the region λ4600–6000 A., the triplet absorbs more strongly than the singlet; therefore the transient corresponded to a temporary increase in absorption which decayed exponentially to its initial value.

Light from an unfiltered flash excited 70 per cent or more of the chlorophyll molecules to their triplet state; orange filters reduced this conversion to about 20 per cent. Since the scanning light was approximately monochromatic and the absorption curves comparatively flat, Beer's law can be used in the analysis of the data without introducing an appreciable error.

$$\frac{1}{l}\log J/I = \alpha_1(m - x) + \alpha_2 x$$

where l is the length of the cuvette, α_1 and α_2 the extinction coefficients of the singlet and triplet, respectively, x the concentration of the triplet and m the total or stoichiometric concentration of the chlorophyll. I is the intensity of the light reaching the photomultiplier after passing through the solution and J is the intensity corresponding to a cuvette filled with the solvent. Introducing I_∞, the intensity corresponding to a solution in which the chlorophyll is in the ground-state, we may write:

$$x = \frac{1}{l(\alpha_2 - \alpha_1)}\log\frac{I_\infty}{I}$$

For a first-order reaction,

$$\ln\frac{x_0}{x} = \ln\frac{\log I_\infty/I_0}{\log I_\infty/I} = \frac{\ln 2}{\tau_{1/2}}t$$

where x_0 and I_0 are the values of x and I at $t = 0$ and $\tau_{1/2}$ is the half time of the reaction. More careful analysis of the data (ref. 2, and private communication from H. Linschitz) indicates that the process is not strictly first-order but conforms to the following equation:

$$-\frac{dx}{dt} = (k_1 + k_2 x + k_3(m - x) + k_Q[Q])x$$

where k_2 and k_3 are approximately 10^9 and 10^7 *m.*$^{-1}$ sec.$^{-1}$, respectively. However, for the chlorophyll concentrations (about $1{\cdot}5 \times 10^{-6}$ *m.*) used in these experiments, values of k_Q (the bimolecular quenching constant) obtained from this relation do not differ significantly from those derived from an assumed first-order law. The values listed in Table 2 were obtained graphically by plotting the reciprocal of the observed half-life against the concentration of the quenching agent:

$$\ln 2/\tau_{1/2} = k^0 + k^q[Q]$$

Table 1 lists the half-lives observed for $1{\cdot}5 \times 10^{-6}$ *m.* solutions of chlorophyll *a* in benzene, containing *p*-benzoquinone at the concentrations indicated, and Table 2 summarizes the results obtained with effective quenchers.

In addition to the compounds listed in Table 2, phenylhydrazine, ethyl-*n*-phenyl carbamate, *m*-dinitrobenzene and triphenyltetrazolium chloride were tested in methanol, and ascorbic acid and allylthiourea were tested in pyridine. At concentrations of 10^{-3} *m.* (and of 10^{-1} *m.* for allylthiourea, ascorbic acid and phenylhydrazine) none of these substances noticeably affected the rate of disappearance of the chlorophyll triplet.

Kinetic studies[1,2] of chlorophyll-sensitized autoxidations indicate that the sensitizer in its triplet state reacts with a molecule of either oxygen or the reductant to form a short-lived intermediate, which in turn interacts with the other reactant to yield the final product. Since oxygen quenches the triplet state and the reducing agents do not, the mechanism involving the direct interaction of sensitizer triplet and the reductant is eliminated. It is, therefore, very probable that a short-lived, reactive 'moleoxide' of the sensitizer is an essential intermediate in such reactions[1,2,6]. The bimolecular rate-constants for quinone, β-carotene, α-carotene and xanthophyll are all in the range $1{\cdot}0$–$1{\cdot}6 \times 10^9$ *m.*$^{-1}$ sec.$^{-1}$, which is about tenfold smaller than the maximum rate-constant of a diffusionally limited bimolecular reaction[7].

Since oxygen and quinone efficiently quench both the triplet and the fluorescent states and ascorbic acid quenches neither, further parallelism between the reactions of these two types of excited states might be expected. However, it does not appear to exist. Triphenyltetrazolium chloride and *m*-dinitrobenzene strongly quench the fluorescence of chlorophyll solutions but do not appreciably alter the half-life of the triplet state.

Table 2. Summary of Quenching Constants for the Triplet State of Chlorophyll *a*

Quencher	Solvent	Range of concentrations	No. of independent measurements	k_Q, *m.*$^{-1}$ sec.$^{-1}$ × 10^{-9}
Quinone	Benzene	$(15$–$2{\cdot}5) \times 10^{-7}$	5	$2{\cdot}4 \pm 0{\cdot}5$
Oxygen	Benzene	$(3{\cdot}6$–$1{\cdot}1) \times 10^{-6}$	4	$1{\cdot}1 \pm 0{\cdot}3$
β-Carotene	Benzene	$(3{\cdot}7$–$0{\cdot}6) \times 10^{-6}$	5	$1{\cdot}3 \pm 0{\cdot}3$
β-Carotene*	Benzene	$(0{\cdot}8$–$2{\cdot}4) \times 10^{-7}$	5	$1{\cdot}5 \pm 0{\cdot}3$
β-Carotene	Pyridine	$1{\cdot}2 \times 10^{-6}$	2	$1{\cdot}0 \pm 0{\cdot}4$
α-Carotene	Benzene	$(8{\cdot}3$–$2{\cdot}8) \times 10^{-7}$	5	$1{\cdot}6 \pm 0{\cdot}3$
Luteol	Benzene	$(9{\cdot}0$–$4{\cdot}5) \times 10^{-7}$	3	$0{\cdot}6 \pm 0{\cdot}3$
Zea xanthophyll	Benzene	$1{\cdot}4 \times 10^{-6}$	2	$0{\cdot}7 \pm 0{\cdot}4$
Cyclo-octatetraene	Methanol	$(3{\cdot}0$–$0{\cdot}1) \times 10^{-3}$	5	$0{\cdot}0012 \pm 0{\cdot}0002$

* Chlorophyll *b* was used in these measurements

Furthermore, β-carotene, which quenches the triplet as strongly as does oxygen, has no noticeable effect upon the amount of fluorescence of chlorophyll *b*.

Schenck has interpreted[8] the results of his extensive studies of dye- and pigment-sensitized oxidations as indicating that quinone is an efficient quencher of the triplet states of sensitizers and that cyclo-octatetraene is a moderately efficient quencher. At least for the case of chlorophyll, both these conclusions are fully confirmed by the present direct measurements.

The universal occurrence of carotene in all autotrophic plants has led to the speculation that it must play an important, if as yet unknown, part in photosynthesis. Recently[9] it has been demonstrated that the Hill reaction is inhibited if the carotene (but not the chlorophyll) is extracted from a chloroplast preparation. The addition of a solution of β-carotene to the extracted chloroplasts restored their ability to undergo the Hill reaction. In view of this information, it appeared to be worth while to test the carotenes for possible interactions with the triplet state of chlorophyll. As is demonstrated by the data of Table 2, β-carotene, *a*-carotene and xanthophyll are as efficient as oxygen in quenching the triplet state of chlorophyll *a*. Measurements with β-carotene and chlorophyll *b* demonstrate that the effect is not limited to chlorophyll *a*. While it still remains an unconfirmed speculation, the postulate that carotene plays a direct part in the primary act of photosynthesis gains support from the present results.

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SPECIFIC INHIBITION STUDIES RELATING TO THE LEWIS BLOOD-GROUP SYSTEM

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ONE of the problems of outstanding interest to the biochemist working in the field of human blood groups is the elucidation of the chemical structures which are responsible for the complete serological independence of the various blood-group characters. Water-soluble substances showing *A*, *B*, *H* or *Le*^{a} blood-group specificity which have been isolated in an essentially homogeneous condition have been found to be qualitatively identical in composition[1]. Thus each contains the same four sugars, L-fucose, D-galactose, *N*-acetylglucosamine, and *N*-acetylgalactosamine, and at least eleven amino-acids. Certain quantitative differences in the proportions of the various sugars are fairly consistently observed in substances belonging to different groups, and these variations may be related to specificity differences[2]. The clearest indications available at present, however, concerning the components which play an important part in the specificity of the blood-group mucopolysaccharides have been obtained by studies of serological and enzyme inhibition reactions with simple sugars and derivatives of known structure.

The first indication that one of the component sugars of human *H* substance is more closely involved than the others in specificity was obtained when it was found that L-fucose inhibited the agglutination of O cells by an eel anti-*H* serum[3]. Examination of the inhibiting capacity of the methyl L-fuco-pyranosides and -furanosides showed that an α-L-fucopyranosyl structure gave the closest fit with the eel antibody although the inhibition was small compared with that given by intact *H* substance. Subsequent experiments with an anti-*H* reagent of plant origin, namely, an extract of *Lotus tetragonolobus* seeds, again indicated a specific role for an α-L-fucopyranosyl structure in *H* specificity[4]. Inhibition of the agglutination of *A* cells by plant seed anti-*A* reagents similarly pointed to the important part played by *N*-acetyl-D-galactosamine in *A* specificity[4]. This observation has been confirmed by quantitative inhibition of the precipitin reaction using human anti-*A* serum; by means of this technique it was also shown that an α-D-galactoside structure inhibited the *B*–anti-*B* system[5].

Independent evidence for the part played by L-fucose, *N*-acetyl-D-galactosamine and D-galactose in *H*, *A* and *B* specificity, respectively, was obtained through enzyme inhibition experiments, in which it was found that the enzymic hydrolysis of each blood-group substance was inhibited specifically by the sugar that had been shown by the serological inhibition tests to be involved in specificity[6]. The enzyme preparations used for the inactivation of the *A*, *B* and *H* substances were obtained from *Trichomonas foetus*[7]. Extracts from this organism also destroy the serological activity of the Lewis *Le*^{a} substance[8], the mucopolysaccharide material which is found in the secretions of individuals who do not secrete water-soluble *A*, *B* or *H* substances. Application of the enzyme inhibition technique to the *Le*^{a} system disclosed that the inactivation of *Le*^{a} substance could also be inhibited by L-fucose. At first sight this observation might suggest a relationship between *H* and *Le*^{a} specificity; serologically, however, these two substances are quite distinct and it is therefore probable that other structural differences, such as the mode of linkage of L-fucose, or the nature of the sugars adjacent to it, exist between *H* and *Le*^{a} substances. The enzyme inhibition results made it of considerable interest to know whether any

known structures containing fucose would inhibit the reaction between *Le*(*a*+) red cells and anti-*Le*^{a} serum. Until recently, oligosaccharides containing L-fucose associated with galactose and/or amino-sugars were not known, but as a result of Prof. R. Kuhn's outstanding researches on the nature of the oligosaccharides in human milk which contain L-fucose, a number of these materials have now been described. At our request, Prof. R. Kuhn very kindly sent us samples of these oligosaccharides together with a seventh compound, isolated from human milk, lacto-*N*-tetraose, which does not contain fucose. The trivial names and constitutions of the compounds are as shown above.

(1) Lacto-*N*-tetraose[9]

β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose

(2) Lacto-*N*-fucopentaose I[10]

β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2)
α-L-fucosyl

(3) Lacto-*N*-fucopentaose II[11]

β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 4)
α-L-fucosyl

(4) Lacto-*N*-difucohexaose

β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2) | (1 → 4)
α-L-fucosyl α-L-fucosyl

(5) Fucosido-lactose[12]

β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2)
α-L-fucosyl

(6) Fucosido-galactose[11]

α-L-fucosyl-(1 → 2)-D-galactose

(7) Lacto-difucotetraose[11]

β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2) | (1 → 3)
α-L-fucosyl α-L-fucosyl

A sample of lacto-*N*-fucopentait II, in which the terminal glucose in lacto-*N*-fucopentaose II had been reduced to sorbitol, was also supplied by Prof. Kuhn. Another fucose-containing disaccharide has been isolated from fucoidin by our colleague, Dr. R. Côté, and was available for study; the constitution of the compound has been established as α-L-fucosyl-(1 → 2)-L-fucose; the fucose present in this disaccharide and in all the sugars in the oligosaccharides from milk are believed to be in the pyranose form.

Kuhn and Osman[13] had tested oligosaccharides (1) to (5) for their capacity to inhibit the agglutination of O cells by eel serum and found that with the exception of fucosido-lactose, which showed slight inhibition, the compounds were without activity in this system in spite of the fact that out of the five tested four contained α-L-fucopyranosyl structures.

In our experiments the method used for testing the materials for their action on the *Le*^{a} system was that of inhibition of agglutination of *Le*(*a*+) red cells by a human anti-*Le*^{a} serum. In many instances the materials were also examined by means of inhibition of hæmolysis of ficin-treated *Le*(*a*+) cells, using a human anti-*Le*^{a} serum[14]. Hæmolysis and precipitin inhibition tests were also carried out with rabbit anti-*Le*^{a} reagents induced by an artificial antigen made by combining *Le*^{a}-substance with the conjugated protein component of the somatic *O* antigen of *Shigella dysenteriae*[15]. The following simple sugars failed to inhibit in the agglutination inhibition tests at a concentration of 1 per cent: D-glucose, D-arabinose, L-rhamnose, D-xylose, D-fructose, L-fucodesose, methyl α- and β-D-galactopyranosides, methyl α- and β-L-fucopyranosides, methyl α-L-fucofuranoside, methyl α- and β-*N*-acetyl-D-glucosaminides, methyl 2-*O*-methyl-L-fucopyranoside, β-D-(1 → 3)-, β-D-(1 → 4)- and β-D-(1 → 6)-galactopyranosyl-*N*-acetyl-D-glucosamine, melibiose, cellobiose, laminaribiose and raffinose.

The results of the agglutination inhibition tests with the oligosaccharides are given in Table 1. It will be seen that one compound, lacto-*N*-fucopentaose II, showed considerable activity, and a second compound, lacto-*N*-difucohexaose, weak but definite power to inhibit. Lacto-*N*-fucopentaose I, lacto-*N*-tetraose, lacto-difucotetraose, fucosido-lactose, α-L-fucosyl-(1 → 2)-galactose, α-L-fucosyl-(1 → 2)-fucose, and D- and L-fucose were inactive. Similar results were obtained in hæmolysis inhibition tests with human or rabbit anti-*Le*^{a} serum, and in precipitin inhibition tests in which a precipitating rabbit anti-*Le*^{a} serum was used. Hæmolysis and precipitin inhibition tests were, however, not carried out on all the substances examined in the agglutination inhibition tests. The failure of lacto-*N*-tetraose to inhibit supports the suggestion that L-fucose is an important part of the determinant specificity of *Le*^{a}-substance, since the tetraose differs from the strongly active lacto-*N*-fucopentaose II only in that the latter contains an α-L-fucosyl radical joined as a branching unit by a (1 → 4) linkage to *N*-acetyl-D-glucosamine. When the fucose is joined by a (1 → 2) linkage to a galactose as in lacto-*N*-fucopentaose I, fucosido-lactose, or α-fucosyl-(1 → 2)-galactose, the substances possess no activity and it is evident that the specificity requirements of the *Le*^{a} antibody cannot be fulfilled. The proximity of a second fucose molecule joined to

Table 1. THE AMOUNTS OF *Le*^{a} SUBSTANCE AND SUGARS GIVING INHIBITION WITH HUMAN ANTI-*Le*^{a} SERUM

Substance	Minimum amount of substance giving inhibition* (μgm./0·1 ml.)
Human *Le*^{a} substance	0·04
L-Fucose	> 1,000
D-Fucose	> 1,000
α-Fucosyl-(1 → 2)-fucose	> 1,000
α-Fucosyl-(1 → 2)-galactose	> 1,000
Fucosido-lactose	> 1,000
Lacto-*N*-tetraose	> 1,000
Lacto-difucotetraose	> 1,000
Lacto-*N*-fucopentaose I	> 1,000
Lacto-*N*-fucopentaose II	1
Lacto-*N*-fucopentait II	1
Lacto-*N*-difucohexaose	60

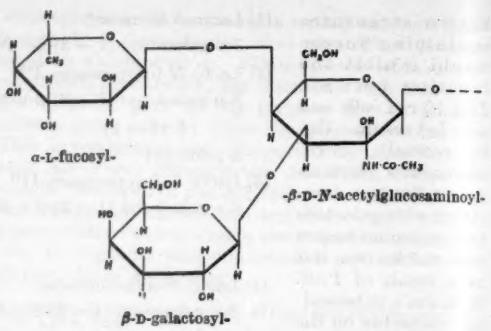
* Equal volume of inhibitor added to volume of anti-*Le*^{a} serum

galactose, as in lacto-*N*-difucohexaose, appears to impair the specific relationship, since the hexasaccharide is a much weaker inhibitor than is lacto-fucopentaose II. The observation that the inhibiting power of lacto-*N*-fucopentaose II is unimpaired when the terminal glucose is reduced to sorbitol, as in lacto-*N*-fucopentait II, supports the belief that glucose, which is absent from *Le*^{a} substance, plays no part in the specific inhibition shown by the pentaose. Treatment of lacto-*N*-fucopentaose II with a crude *T. foetus* enzyme preparation destroyed its capacity to inhibit in the *Le*^{a} system; chromatographic examination of the enzyme-treated material showed that the pentaose had been completely broken down into its component sugars.

It is known that the *ABH* blood-group mucopolysaccharides occur in human milk[16] and the closely similar *Le*^{a} substance will most probably also be present, especially in the milk of *Le*(*a*+) women. The possibility that the lacto-*N*-fucopentaose II was contaminated with traces of highly active *Le*^{a} substance had therefore to be considered. To test this possibility, 10 mgm. of lacto-*N*-fucopentaose II were dialysed through a 'Visking' membrane and recovered. The whole of the activity readily diffused and could therefore not be due to *Le*^{a} substance, which is known to be indiffusible through 'Visking' membranes. Additional evidence to support this conclusion is obtained from the fact that the closely similar lacto-*N*-fucopentaose I which is isolated from milk by the same technique as is lacto-*N*-fucopentaose II is nevertheless inactive in the *Le*^{a} test.

Preliminary observations on the inhibition by simple carbohydrates of the agglutination of *Le*(*b*+) cells by human anti-*Le*^{b} serum[17] showed that, of the fucose containing oligosaccharides, lacto-*N*-difucohexaose, and lacto-difucotetraose were the only two which gave definite but weak inhibition. The significance of these observations must await further work on this system, but a possible interpretation is that two fucose residues, arranged spatially as in these compounds, are concerned in *Le*^{b} specificity.

In conclusion, the results of the serological inhibition tests indicate that an α-L-fucopyranosyl structure is concerned in *Le*^{a} specificity and that two such units are possibly involved in *Le*^{b} specificity. The α-L-fucosyl structure alone, however, is unable to neutralize the *Le*^{a} antibody, as is demonstrated by the inactivity of methyl α-L-fucopyranoside, α-fucosyl(1 → 2)-fucose, the oligosaccharides (2, 5, 6 and 7) containing fucose joined by a (1 → 2) linkage to galactose and lacto-difucotetraose, which contains, in addition, an α-fucosyl residue joined by a (1 → 3) linkage to glucose. An α-L-fucose unit joined by a (1 → 4) glycosidic linkage to *N*-acetyl-D-glucosamine, as in lacto-*N*-fucopentaose II, is compatible with a high degree of inhibition, and it would appear, therefore, that this structural unit is an important requirement for the neutralization of *Le*^{a} antibody. The second oligosaccharide in the series tested which contains this unit, lacto-*N*-difucohexaose, is, however, a much poorer inhibitor than is lacto-*N*-fucopentaose II. This could be due to the steric hindrance of the L-fucose joined to the non-reducing galactosyl end-unit of the lacto-*N*-tetraose backbone whereby the antibody is unable to approach closely enough to make a firm combination with the specific grouping. Alternatively, one could speculate that the activity of the pentaose II resides in the specific spatial pattern given by the structure:



and that a branched trisaccharide unit formed by two non-reducing end-units, α-L-fucosyl- and β-D-galactosyl, attached to *N*-acetyl-D-glucosamine functions as the specific determinant grouping in *Le*^{a} serological reactions. It should be borne in mind, however, that the structure present in lacto-*N*-fucopentaose II probably corresponds only in part to the specific configuration present in *Le*^{a} substance, because the inhibition given by the pentasaccharide is only a fraction of that given by the homologous substance. Serologically active oligosaccharides containing fucose, galactose and amino sugar have been isolated from *Le*^{a} substance by partial hydrolysis at 100° with barium carbonate (*p*H 8·5)[18], and it is hoped that work now in progress will provide direct evidence for the nature of the dominant serological structures responsible for *Le*^{a} specificity.

We wish to thank Prof. R. Kuhn for the oligosaccharides from human milk, without which this investigation would not have been possible, and Dr. J. Lundevall, Oslo, for a generous supply of human anti-*Le*^{a} serum. These studies were aided by a grant from the Nuffield Trust.

Note. This communication was first submitted to *Nature* and accepted for publication in October 1956; it was afterwards withdrawn by the authors because Prof. Kuhn wished to obtain further proof for the structures earlier suggested for pentaoses I and II. The original structure for pentaose II was found to be correct and the main conclusions reached by the authors at that time have therefore remained essentially unchanged. A number of small observations made during the past few months have been added.

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LETTERS TO THE EDITORS

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Examination of the Oligosaccharides isolated from Jute α-Cellulose

In a previous communication[1], it has been shown that a number of sugar residues, in addition to those reported earlier[2,3], can be identified in jute α-cellulose on modifying both the conventional hydrolytic procedure and the technique of developing the chromatogram. The nature of association among the various sugar components in jute cellulose has not so far been established, however. Das *et al.*[2] claim to have isolated an oligosaccharide containing glucose, xylose and arabinose from the hydrolysate of jute α-cellulose with formic acid, whereas Adams and Bishop[3] have failed to substantiate this result. The work now briefly described deals with the isolation of oligosaccharides from the incomplete hydrolytic products of jute α-cellulose after a mild treatment with sulphuric acid, and has the object of elucidating the mode of association of the different sugar components with the glucose unit of the cellulose chain.

α-Cellulose (10 gm.) employed in this work was prepared by the action of 9·5 per cent caustic soda on chlorite holocellulose obtained from tossa jute and partially hydrolysed with $N/2$ sulphuric acid (200 ml.) for 1 hr. at 98°–99° C., when 3 per cent of the material went into solution. The extract, after direct neutralization with barium carbonate, was chromatographed on Whatman No. 1 filter paper as described earlier[1]. The chromatogram thus obtained showed the presence of all the sugar components, with the exception of barium uronate, previously reported[1], along with ten spots of oligosaccharides, either pink or yellow in colour and occurring between the starting line and the position of uronate.

A pentose can readily be differentiated by its characteristic pink colour from a hexose, which yields a yellow to brown colour, but the faint yellow colour of the outer zone of a spot and that arising from a substance occurring in trace amounts, are extremely difficult to distinguish with the naked eye. Under ultra-violet light, however, the faint yellow colour becomes distinctly visible due to a greenish-yellow fluorescence. The outlines of spots of oligosaccharides, particularly those of yellow colour, were therefore obtained on examination under ultra-violet light, because under this condition fluorescence similar to that of a simple hexose residue was exhibited by an oligosaccharide. The portion of the chromatogram containing the oligosaccharides is represented by Fig. 1.

Of the various oligosaccharides obtained, those corresponding to spots 1, 6, 8 and 10 were isolated after separation on Whatman No. 3*MM* filter paper, the former two spots being yellow and the latter two pink in colour. The individual oligosaccharides, which yielded single spots on being separately chromatographed, were completely hydrolysed with boiling N sulphuric acid and the component sugars chromatographically identified. Although the oligosaccharides corresponding to spots 1 and 8 give rise to different colours and are of widely different R_F values, the constituent sugars of both these substances are found to be galactose, glucose and xylose

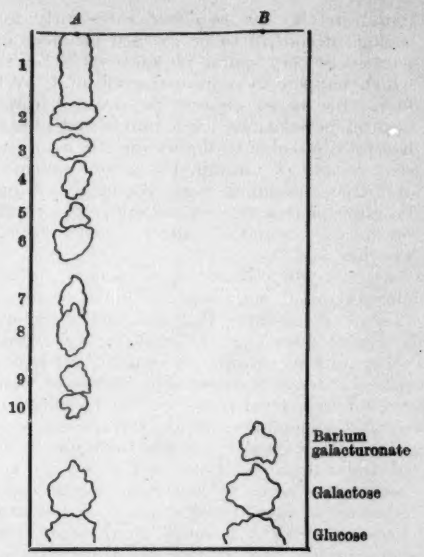

Fig. 1. Chromatogram with *n*-butanol–acetic acid–water (1 : 0·24 : 1), using aniline hydrogen phthalate as a spraying agent. *A*, jute α-cellulose hydrolysate; *B*, reference sugars. Of the oligosaccharide spots 2, 5, 8 and 10 were pink and the rest yellow to brown in colour

with traces of mannose. The spot of the last sugar is, however, so faint, particularly when derived from spot 8, that it becomes detectable only under ultra-violet light. The oligosaccharide of spot 6 is composed of galactose, glucose and xylose, while that obtained from spot 10 consists of glucose and xylose possibly with traces of mannose.

Since glucose has been found to be one of the main components of the oligosaccharides studied, the above results seem to offer a direct evidence of the chemical association of galactose, xylose and possibly mannose with the glucose residues of jute α-cellulose. Since it has been noticed that most of the arabinose and rhamnose components are hydrolysed by the action of $N/2$ sulphuric acid, the chemical linkage, if any, between these two sugars and cellulose, appears to be readily broken.

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Vitamin B_{12} in Marine Ecology

At least half the marine algal flagellates and diatoms which have been studied in pure culture have been shown[1] to require an exogenous source of vitamin B_{12}, which is the reason for an interest in the occurrence of this vitamin in the sea as one of the factors controlling phytoplankton populations and the productivity of water masses. However, the amount of vitamin required is very small; just how small is not generally realized, and it may be that the amount

found in the sea is never sufficiently low for an ecological control to be exerted on any of the comparatively very sparse populations of phytoplankton which happen to require the vitamin. Whether, in fact, this is so cannot be decided directly with natural populations for a number of reasons, but it has been possible to determine the magnitude of the requirement of vitamin B_{12} in one marine organism and then, assuming algae requiring vitamin B_{12} to be alike in this respect, to apply the result to data on marine populations and to assays of sea water for vitamin B_{12}.

Curves for *Monochrysis lutheri*, a euryhaline chrysomonad, suggested a linear relation between dosage of vitamin B_{12} and cell number, but the available data (Fig. 1, small circles) were based on computations from previously published optical measurements of growth[2,3]. Moreover, they did not extend to a level likely to be of ecological interest, so that some extrapolation was necessary. However, when rather greater care was taken in the preparation of the culture medium and inoculum and growth assessed directly by hæmocytometer counts it was possible to extend the range to 0·1 μμgm./ml., the lowest figure yet recorded in the sea[4] (Fig. 1, large open circles). In deriving the three curves in Fig. 1, it was necessary to correct each for carry-over before performing the logarithmic transformations. This was because the amount of vitamin B_{12} in any culture is the sum of what is added intentionally and what is introduced as carry-over (including also contamination from water, glassware and chemicals). The size of the correction to be applied to the dosage scale in each case was ascertained by a short extrapolation to the abscissa of the regression of cell numbers on dosage of vitamin B_{12}. It was, respectively, for the 1954 experiment 1·6 μμgm./ml., for the 1955 experiment 0·4 μμgm./ml. and for the 1957 experiment 0·05 μμgm./ml.

The 1957 experiment agrees well with the previous ones; all the points lie about a straight line with a slope of unity on logarithmic co-ordinates, thus indicating a linear relation between cell numbers and concentration of vitamin B_{12}, at least between the limits 0·1 and 10 μμgm./ml. Between these limits each μμgm. supports 800,000 cells of *Monochrysis*, that is, about 540 molecules per cell, or reckoning 200 μ^3 as the mean size of *Monochrysis*, 3 molecules per μ^3 of living alga. By way of comparison, *Euglena gracilis* (2,000 μ^3) requires 4,900 molecules per cell[5] and *Stichococcus* sp. (12 μ^3) 40 molecules[6], which are requirements of the same order of magnitude as that of *Monochrysis*.

Vitamin B_{12} has been measured in the sea on several occasions. Applying the *Monochrysis* data to Cowey's measurements[4], the summer waters of the North Atlantic or northern North Sea (0·1 μμgm./ml.) contain sufficient vitamin B_{12} for at least 80,000 cells of *Monochrysis* per ml.; also from the same source, for the northern North Sea in autumn (0·5–1·0 μμgm./ml.) up to 800,000 cells and the Butt of Lewis in spring (1·0–2·0 μμgm./ml.) up to 1,600,000 cells, and from Lewin[6] and Droop[3] for inshore waters (5–10 μμgm./ml.) up to 8,000,000 cells.

References to the size of phytoplankton crops are numerous in the literature[7]; those of the diatom *Skeletonema costatum* can be compared directly with the *Monochrysis* estimates since the two species are much of a size. In the Clyde area, where the spring bloom is *Skeletonema*, maxima of less than 2,000 cells

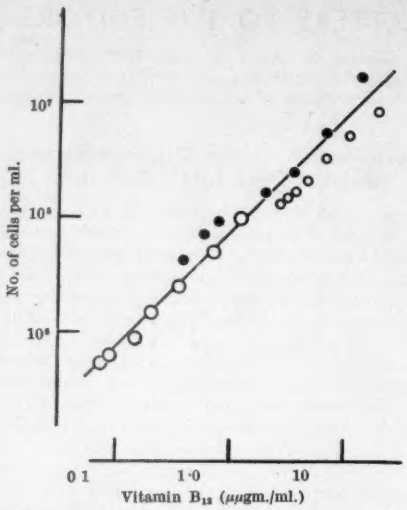

Fig. 1. Response of *Monochrysis lutheri* to vitamin B_{12}. Small open circles, 1954 experiment (ref. 2); small closed circles, 1955 experiment (ref. 3); large open circles, 1957 experiment

per ml. occur in poor years, while in good years up to 10,000 cells may be recorded, the highest records being of the order of 25,000 cells (Dr. S. M. Marshall, personal communication). According to my reckoning, it would require less than 0·1 μμgm. of vitamin B_{12} (Cowey's lowest figure) to achieve a crop of 25,000 cells. Even when the relative sizes of the species are taken into account, the only instances quoted by Bainbridge[7] of populations which would require more than 0·1 μμgm. vitamin B_{12}/ml. are those of the Florida red tides. 60,000 cells per ml. of *Gymnodinium brevis*, the highest record[8], would require at most 3 μμgm. vitamin B_{12}/ml. (a *Gymnodinium* cell occupies[9] 7,500 μ^3, which is equivalent to 40 *Monochrysis* cells). Even so it is questionable whether coastal waters often contain less than this amount of the vitamin.

In short, with this possible exception of the red tides, the data available at present point to there being at all times more than sufficient vitamin B_{12} in the sea for the crops which are encountered.

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In the accompanying communication, Droop gives a calculation to demonstrate that vitamin B_{12} is present in the sea in amounts more than sufficient for the known plankton crops. It might be inferred from it that vitamin B_{12} is not a factor which influences the amounts and types of life present in

the sea. There probably are, however, several modifying circumstances of which Droop, because of the incompleteness of available information, could take no account. His calculations are based on determinations of the maximum yield of organisms obtainable per unit amount of vitamin in laboratory pure culture; but it is the influence of the vitamin on the rate of growth, not on the final yield, which will be more relevant to marine ecology. In a natural environment a concentration of vitamin B_{12} (or indeed of any other nutrient) sufficient to support considerable cell-division may nevertheless be a limiting concentration, if the rate of cell-division so supported is only sufficient to compensate for the losses of cells due to other factors such as predation, sinking and the like.

The figures Droop uses for concentrations of vitamin B_{12} in ocean waters are those of Cowey[1]; but reference to Cowey's paper shows that they were obtained after subjecting filtered water to an extraction procedure in which the first stage is heating with cyanide. This procedure would be expected[2] to free the vitamin B_{12} from any combination with, for example, filter-passing cells, cell fragments and the sequestering substances ('binding factors') which are found in some protist culture liquors[3]. Cowey's values are therefore of total filtrable vitamin content. If, however, some of this vitamin was present in combined forms, the amounts of vitamin which were free and therefore certainly available for plankton nutrition would be less than the total amounts recorded by Cowey.

A further complication is that 'bound' vitamin B_{12}, though of no use to some plankton species, might be utilizable by others.

It seems to me that the sea's vitamin B_{12} should remain a subject of interest to investigators concerned with marine productivity; much more information, on this vitamin and on marine ecology in general, must be collected before any final conclusions can be drawn about the influence of vitamin B_{12} concentrations on life in the sea.

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Vitamin B_{12} Distribution between Plasma and Cells

Published values for vitamin B_{12} and blood dyscrasias are nearly all based upon values in serum[1]. Since B_{12} assays can be carried out without inhibition of the assay organisms by whole blood and without interference by colour[2–4], we investigated the distribution of B_{12} between plasma and the cellular elements of blood.

Citrated or heparinized blood from (*a*) healthy individuals, (*b*) patients with untreated pernicious anæmia, and (*c*) a patient with total gastrectomy was assayed with *Euglena gracilis* and *Ochromonas malhamensis* by methods outlined previously[2,3,5]. The pernicious anæmia patients were untreated at the time blood was drawn. The totally gastrectomized patient had been given B_{12}, but because serum-levels had been low his blood was included in this series.

Table 1. Vitamin B_{12} Content of Plasma and Blood Cells
Vitamin B_{12} ($\mu\mu$gm./ml.)

Subject	State	Plasma (P)	Blood cells (C)	Total blood (calc.)* (T)	Hæmatocrit (H)
1. *H. B.*	Normal	620	76	380	44
2. *H. S.*	Normal	600	59	375	42
3. *I. P.*	Normal	320	88	210	47
4. *J. A.*	Pernicious anæmia, untreated	23	15	22	16
5. *A. S.*	Pernicious anæmia, untreated	32	15	30	13
6. *R. J.*	Gastrectomy	50	33	47	20

* Values for total blood are calculated from $T = \frac{(H\,C) + (100-H)\,P}{100}$

The blood cells were separated from the plasma by centrifugation and the hæmatocrit values recorded. The cells were then washed six times with acid citrate glucose solution and resuspended in a volume of this solution equal to the original volume of whole blood. The plasma and blood cells were prepared for assay as described[2].

As shown in Table 1, the plasma for normal subjects contains four to ten times more B_{12} than the cellular elements; in the patients with pernicious anæmia or total gastrectomy the plasma contains 1·5–2 times as much B_{12} as the blood cells. A comparison of the hæmatocrit values of the normal and pernicious anæmia groups with the corresponding cellular B_{12}-level, shows that both groups are not much different in B_{12} content per hæmatocrit unit; it is remarkable that cells survive at such low plasma B_{12}-level, although, of course, their number is reduced by lowered B_{12} supply. As for the proportion of B_{12} in the cells as compared with B_{12} in total blood, one finds percentages of 7–14 in the cells from the patients with pernicious anæmia and gastrectomy, while the values for normal whole blood vary from 7–19 per cent. Thus the number of cells in the circulation reflects the available vitamin B_{12}.

The high proportion of B_{12} in the cells of the pernicious anæmia group, as compared to B_{12}-levels in plasma suggests that B_{12} used for red cell formation and maturation is efficiently drawn upon even when the pool of the vitamin is severely depleted. The abnormal cytological picture in pernicious anæmia may be explained by there being enough B_{12} to initiate cell formation, but not enough for the cells to mature normally. Only plasma well supplied with B_{12} supports normal maturation in bone marrow and cells.

In pernicious anæmia the bone marrow competes with other tissues for the limited store of B_{12}. When nerve tissue becomes depleted of B_{12}, sub-acute combined degeneration of the cord ensues. Treatment of pernicious anæmia with folic acid may induce both a hæmatological remission and sub-acute combined degeneration of the cord[6]. This suggests that the small store of B_{12} is mobilized towards the bone marrow, alleviating its deficiency, but markedly aggravating B_{12} depletion in other tissues.

Plasma-levels do, then, reflect closely the vitamin B_{12} supply of the tissues, even though the blood cells from patients with pernicious anæmia do not contain substantially less B_{12} than normal cells if the hæmatocrit value is considered.

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Changes in Cellular Nucleic Acids during Infection with Poliomyelitis Virus as studied by Fluorescence Microscopy

REMARKABLE similarities have been found between the biological properties of animal viruses containing ribonucleic acid and those of viruses containing deoxyribonucleic acid (such as bacteriophages). The question has thus been raised whether the mechanism of duplication of the two types of virus may involve common steps[1]. One possibility is that viruses containing ribonucleic acid have an intracellular deoxyribonucleic acid phase. With this point in mind, extensive cytochemical investigations of the changes occurring in the nucleic acids of cells infected by poliomyelitis virus have been carried out.

Monolayer cultures of monkey kidney cells grown on coverslips were infected with type 1 Mahoney virus in a concentration adequate to infect almost all the cells in half an hour. The virus release from these cells is known to begin between five and six hours after infection[2]. At various times after infection, specimens were collected and examined, either living or after methyl alcohol or Carnoy's fixation, and some also after freeze-drying. In all cases the samples were stained for 3 min. with diluted acriflavin (10^{-4} or 10^{-5} in weight in phosphate buffered saline, *p*H 7·4). After thorough washing and subsequent differentiation in 0·5 *M* calcium chloride, they were observed under the fluorescent microscope (cf. ref. 3).

The following observations were made. Normal uninfected cultures, or infected cultures up to 3 hr. after infection, show only a very faint fluorescence, dull green in the nucleus, reddish yellow in the nucleolus, faint red ochre in the cytoplasm. Three hours after infection a hazy greenish fluorescence appears in the nucleus. Four hours after infection the nucleus shows a bright green fluorescence, while the cytoplasm takes on a brighter red colour. The red fluorescent material shows a marked tendency to lump, and is discarded from the cells into the medium at this and subsequent hours as coarse granules and bigger clumps. Five hours after infection the bright green fluorescence of the nucleus disappears in more than 50 per cent of the cells; the nuclei appear empty except for the clearly visible nucleolus. The cytoplasm is mostly depleted of the red fluorescent material, and instead a bright green fluorescence is seen, at first as a ring around the nucleus and later spreading over the central part of the cell. Often a bright green, spherical body can be seen lying para-nuclearly, corresponding to the well-known acidophilic inclusion, described by different authors, in fixed and stained preparations.

The use of enzymes shows that the red fluorescence disappears after treatment with ribonuclease, and that the green fluorescence disappears or is greatly attenuated by the action of deoxyribonuclease; controls treated with the buffer solutions in which the enzymes were dissolved showed no changes.

The observations made on fixed and stained preparations confirm the finding of Reissig *et al.*[4], that the disappearance of the chromatin network in the nucleus is one of the earliest visible changes observed in cells infected with poliomyelitis virus.

The behaviour of fluorescence and the effect of specific enzymes suggest that a modification of the nuclear deoxyribonucleic acid is an early consequence of infection. The changes seen a little later in the cytoplasmic red fluorescent material would suggest changes in the cytoplasmic ribonucleic acid. The appearance of a green fluorescence sensitive to deoxyribonuclease in the cytoplasm suggests a marked alteration in the permeability of the nuclear membrane occurring 3–4 hr. after infection. This is supported by the finding that while the nuclear membrane is of normal appearance in living and frozen dried infected cells, it appears greatly distorted and wrinkled when fixed in methyl alcohol or Carnoy's fluids. It is likely that the wrinkling is produced by a quick loss of nuclear materials during fixation, secondary to the permeability changes.

The significance of the observed changes in deoxyribonucleic acid cannot be assessed at present. It is suggestive that the increased fluorescence of the nuclear deoxyribonucleic acid reveals an essential step in virus reproduction, since it is one of the first visible signs of infection. The subsequent migration of deoxyribonucleic acid to the cytoplasm may either indicate the migration of virus precursors in the same direction or may be a consequence of the alteration of the nuclear membrane and not primarily connected with the reproduction of the virus. A better understanding of the observed phenomena must await further work. Details of this investigation, which was supported by a grant from the National Foundation for Infantile Paralysis, will be published elsewhere.

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Pasteurella septica: the Occurrence of Type-Specific Polysaccharides containing Aldoheptose Sugars

PIROSKY[1] has shown that strains of *Pasteurella septica* produce lipopolysaccharide antigens with similar properties to the endotoxins of certain other Gram-negative bacteria. We have isolated lipopolysaccharides from some strains of *P. septica* and studied their serological specificity in relation to the immunological status of the strains as measured by passive protection tests[2,3].

Strains of *P. septica* were grown by shake culture in tryptic meat broth at 37° C. for 2 days. Cells were harvested by centrifugation, dried with acetone, and crude lipopolysaccharide obtained from the dried cells (10–20 gm. amounts) by extraction with 45 per cent phenol[4]. Crude extracts, dialysed to remove phenol, were centrifuged at 100,000*g* for 4 hr. and the nucleic acid-free sediment suspended in water and dried from the frozen state.

Serologically active lipopolysaccharides were obtained in about 2 per cent yield from both a virulent, capsulated type V strain[3] (*P1/V/V*) and its avirulent variant (*P1/V/A*). The isolated materials were white powders, poorly soluble in water. An analysis of *P1/V/V* showed N, 2·5; P, 4·0 per cent; nucleic acid, not detected by absorption at 260 mμ. Both lipopolysaccharides were highly pyrogenic in rabbits but failed to kill them or mice or guinea pigs at a level of 500 μgm. Each material was precipitated at 1/125,000 dilution by an antiserum prepared in rabbits by the successive intravenous injection of heat-killed and live *P1/V/V* cells. Neither of the *P1/V* lipopolysaccharides precipitated strongly with a *P. septica* type I antiserum.

The reaction between the two *P1/V* lipopolysaccharides (1 mgm. amounts) and the anti-*P1/V* serum was followed by diffusion precipitin analysis in agar[5,6]. Each lipopolysaccharide gave a single, clear line of precipitation after 4 days development. The lines showed the reaction of identity both with each other and with one of the twelve lines which formed when live *P1/V* cells were examined against the same serum. Non-type-specific antibodies were largely removed from the *P1/V* antiserum by absorption with acetone-dried cells of a virulent type I strain (*P28/I/V*) and the absorbed serum was examined against *P1/V* lipopolysaccharide and live cells of representative strains from five different immunological types of *P. septica*. It was found that only the immunological type V strains possessed the *P1/V* lipopolysaccharide, this material being absent from strains of types I, II, III and IV. Heating of cells for 1 hr. at 100° C. did not prevent the formation of the lipopolysaccharide line of precipitation. Fig. 1,*A* shows the presence of lipopolysaccharide (*P*) and another thermostable, type-specific antigen (*S*) in a number of type V strains and their absence from a supposed type V strain, *P81/V/A*. A rough variant NCTC 5393 of unknown immunological type produced the *S* but not the *P* antigen, unlike its smooth parent NCTC 5394, which produced both. When the absorbed *P1/V/V* serum was further treated with purified *P1/V* lipopolysaccharide the line of precipitation normally given by type V cells was specifically suppressed (Fig. 1,*B*).

Diffusion precipitin analysis was applied further to other types of *P. septica*. Live and heated *P. septica* cells of type I and type III were examined against

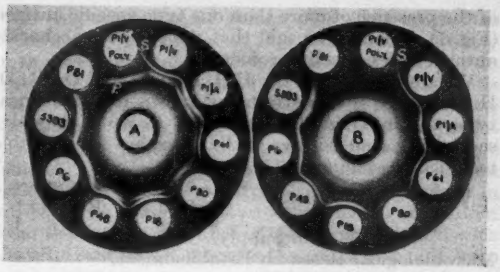

Fig. 1. Diffusion precipitin analysis of *Pasteurella septica* strains. Serum reservoir *A* contained *P1/V/V* antiserum absorbed with *P28/I/V* cells and *B* the same antiserum further treated with purified *P1/V* lipopolysaccharide. Antigen reservoirs contained *P1/V* lipopolysaccharide or cells of various type V strains. The lipopolysaccharide line is labelled *P* and a second thermostable type specific antigen *S*

antisera to types I, III and V, each absorbed with cells of heterologous type. The four type I strains examined possessed a common, thermostable antigen which was absent from types II, III, IV and V, and similarly, the five type III strains possessed a thermostable, type-specific antigen not found in types I, II, IV and V.

Aldoheptose sugars have been detected previously in polysaccharides isolated from *P. septica* (Davies, D. A. L., and Knox, K., personal communications). Examination by paper chromatography of neutralized acid hydrolysates of *P1/V* lipopolysaccharide revealed both an aldoheptose and glucosamine. (Hydrolysis for 18 hr. at 100° C. in 0·5 *N* sulphuric acid: chromatography solvent, butanol 3; pyridine, 2; water, 1·5; spray reagents, anisidine and the Ehrlich reagents.) The presence of aldoheptose was confirmed by the sulphuric acid–cysteine reaction of Dische[7]. The *P1/V* aldoheptose sugar behaved similarly to authentic D-glycero-L-mannoheptose on butanol–pyridine–water chromatograms; but it must be strongly emphasized, in view of the poor chromatographic separation of many aldoheptose sugars, that this is not a proof of identity.

A very poorly soluble lipopolysaccharide containing aldoheptose, glucosamine, and galactose has been obtained from a *P. septica* strain of unknown immunological type. When made soluble by ultrasonic treatment of aqueous suspensions this gave a single line of precipitation on diffusion plates with type I antiserum but no reaction with type V antiserum. An aldoheptose, glucosamine and galactose have also been found in polysaccharides obtained from type I and type IV strains. It seems probable, therefore, that in common with other members of the *Pasteurella* group (Davies, D. A. L., personal communication and ref. 8), aldoheptose sugars are of general occurrence in lipopolysaccharides produced by strains of *P. septica*.

The general composition and properties of the lipopolysaccharides described resemble those of the more fully characterized 'rough' lipopolysaccharide of *Pasteurella pestis*[8], although serological tests show them to be distinct. When these properties are considered in conjunction with the reported presence in strains of *P. septica* of endotoxins[1], it seems probable that the serological specificities we have described can be attributed to the lipopolysaccharide components of these substances. These specificities parallel the immunological type specificity established by passive protection tests[2,3], although, in view

of the presence of more than one type-specific antigen (Fig. 1), it cannot be said that the lipopolysaccharide antigen is necessarily protective.

We are indebted to Dr. J. R. Hudson and Dr. R. D. Huck for *P. septica* strains of known immunological type, to Dr. D. A. L. Davies for *P. pestis* lipopolysaccharide, and to Mr. D. C. Hawkins for valuable technical assistance.

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The Polyhedral Virus of *Prodenia litura* (Fabr.) (Lepidoptera : Noctuidae)

The occurrence of a polyhedrosis in larvæ of *Prodenia litura* (Fabr.) was first observed by Gough[1], Dudgeon[2], and Willcocks and Bahgat[3] in Egypt and was also reported by Crumb[4] from Europe and Caresche[5] from Indo-China. Recently, Abul-Nasr[6] found that this disease is a typical nuclear polyhedrosis. It occurs quite frequently in *P. litura* outbreaks in Egypt and causes heavy mortality in laboratory rearings. Because of the economic importance of the insect and the possible use of the virus for control purposes, it was decided to investigate the causative agent.

The *P. litura* larvæ used for this investigation were collected in the autumn of 1956 in the cotton fields near Cairo and Alexandria. Dead larvæ, mostly of the last stage, which showed the typical symptoms of polyhedrosis were dried in a desiccator and sent to Sault Ste. Marie. They were suspended in water for some weeks. After putrefaction, the suspension was filtered through fine orlon mesh and the insect remnants thoroughly washed to obtain a maximum yield of polyhedra. Since the sample consisted chiefly of heavily infected larvæ, it was easy to purify the polyhedra by differential centrifugation. About 130 mgm. of fairly pure polyhedra were obtained from 4·6 gm. dried larvæ.

The polyhedra are of irregular shape and vary in their diameter from about 1·2 to 3·2μ, the majority measuring about 1·8μ (Fig. 1). The standard method[7] is followed for the liberation and purification of the virus particles. The polyhedra (5 mgm./ml.) dissolve readily in a mixture of 0·008–0·01 *M* sodium carbonate and 0·05 *M* sodium chloride within about 3 hr.

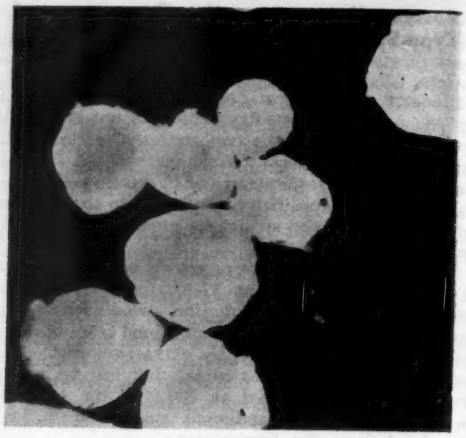

Fig. 1. Polyhedral bodies of *Prodenia litura*. (× 10,000)

The impurities are removed by centrifugation for 5 min. at 4,000 r.p.m. (3,000*g*). The yellow and slightly turbid supernatant, consisting of polyhedral protein and virus, is spun at 11,000 r.p.m. (10,000*g*) for 1 hr., and the resulting yellow-white virus pellet is suspended in the same volume of distilled water after discarding the supernatant (polyhedral protein). The virus is sedimented again under the same conditions, and the final virus pellet is suspended in one-seventh of the original volume of distilled water. Approximately 20 μgm. virus particles were obtained from 1 mgm. polyhedra.

Investigation in the electron microscope showed that the virus is rod-shaped and occurs frequently in bundles. It is a typical representative of classical polyhedral virus of the *Borrelina* group, and the name *Borrelina litura* is suggested. Numerous pictures revealed that this virus has all the typical morphological differentiations (developmental and intimate membrane, spherical stages, etc.) characteristic of this group (Fig. 2). There are comparatively few

Fig. 2. Virus particles liberated from *Prodenia litura* polyhedra; several virus bundles are still surrounded by the developmental membrane, others have shed this membrane leaving single virus particles behind. Some of these disintegrate showing the flattened intimate membrane; one spherical developing stage is seen at upper right. (× *c.* 33,400)

single virus particles; the majority occur in bundles of several particles. The average dimensions of single virus rods still possessing the developmental membrane are about 320 ± 20 mμ × 100 ± 10 mμ. The diameter of most bundles is about 130 ± 10 mμ.

The condition of the larvæ did not permit us to determine whether this disease is a nuclear or cytoplasmic polyhedrosis. However, by analogy to other insect viruses, it is probable that it is a typical nuclear polyhedrosis. It is interesting that Abul-Nasr[6] describes polyhedra in the nuclei of mid-gut cells, which is unusual in Lepidoptera.

For technical reasons it was impossible to test the infectivity of the isolated particles, but the morphological characteristics leave no doubt that they are the causative agent.

One of us (B. F.) thanks the Ministry of Agriculture in Cairo, especially Dr. I. Bishara and Dr. M. Hafez, for their help in the *Prodenia* research problem.

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In vitro Demonstration of Uterine Anaphylaxis in Guinea Pigs sensitized with Homologous Testis or Sperm

Sperm-immobilizing, agglutinating and precipitating antibodies have been detected in the sera of animals injected with sperm or testis[1]. Scrutiny of the literature revealed no studies which considered the possibility that injections of sperm or testis could induce an anaphylactic response. The present study was undertaken to examine this possibility.

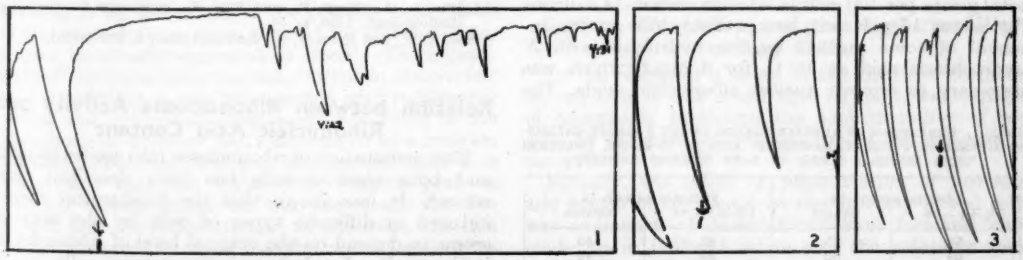
Twenty-eight female guinea pigs were treated as follows: five females were injected intracutaneously in the nuchal region with an emulsion of homologous testis which was prepared by homogenizing testis tissue in an equal volume of saline, and incorporating the mixture in an equal volume of Freund adjuvant (paraffin oil, 'Arlacel A.' and *M. butyricum*)[2]. Five females were injected in a similar manner with an emulsion of washed epididymal guinea pig sperm in adjuvant. Eighteen females were selected at random from the colony, and nine of these were injected with the adjuvant alone, whereas the remaining nine were not injected.

Between 17–38 days after injection, the animals were killed, and their uteri were removed and suspended in a bath containing Locke's solution as the perfusion medium. The bath was maintained at 37° C. and was oxygenated. After a period of equilibration during which the rhythmic pattern of uterine contraction was recorded with a kymograph, 1 ml. of a suspension of epididymal sperm (which were washed twice with saline after removal from the epididymis and then resuspended in 4 ml. of Locke's solution) was added to the bath containing the uterine horn.

All the animals injected with testis or sperm were found to have uteri which reacted strongly to the challenge by contracting maximally within 30 sec. In five of the ten cases, the uteri remained contracted for the length of the period of observation (up to 4 hr.) despite flushings of the bath fluid (Fig. 1). By contrast, only transitory responses (dissipated within 5 min.) were found in five of the eighteen control animals (Fig. 2). All other controls were negative (Fig. 3).

The question may be raised whether the uterus of the sensitized animal reacts to sperm at copulation with a contracture type of response. If the contracture occurred at ovulation and was maintained for some time thereafter, fertility might be impaired, for implantation in a highly contracted uterus might be thwarted.

Numerous investigations have explored the possibility of immunizing females with sperm in order to confer infertility, but the results have been so contradictory as to impel Cushing and Campbell[3] to remark, "it may be stated with considerable assurance that the active immunization of females (including humans) against homologous sperm does not bring about sterility, even though antibody can be demonstrated in the serum". In the absence of convincing



Figs. 1–3. Kymograph records of the responses *in vitro* of guinea pig uteri to homologous sperm. The arrow leading to the numeral 1 in each tracing indicates the point at which sperm were put into the bath.

Fig. 1. Uterus of guinea pig killed 26 days after one injection of homologous sperm in adjuvant. The uterus contracted within 30 sec. after sperm were put into the bath. The contracture was maintained for 4 hr. (the length of the observation period).

Fig. 2. An illustration of the transitory response to sperm of an uninjected guinea pig's uterus.

Fig. 3. An illustration of the lack of effect of sperm on the uninjected guinea pig's uterus.

evidence, however, experiments to this end are being continued.

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Lack of Differential Radiation Effect on the Incorporation of Labelled Precursors into Deoxyribonucleic Acid

It has been reported that formate carbon-14 is preferentially taken up into deoxyribonucleic acid thymine by bone marrow cells *in vitro*[1,2]. This has been further confirmed by the 'thymidine dilution test'. Suspensions of human bone marrow cells were cultured *in vitro*[3], and the formate carbon-14 uptake was measured on high-resolution autoradiographs using the stripping film method on alcohol-fixed smears from such cultures[4]. The proportion of labelled cells ('per cent positive') was obtained by counting 250 cells, and the average count per cell by grain counts over 50 cells. The error-range of such counts is within ± 10 per cent. It was found that 0·18 mgm./ml. medium thymidine depressed formate carbon-14 uptake by 80 ± 11 per cent (seven experiments), while leaving adenine carbon-14 uptake unaffected (four experiments).

Comparison of adenine carbon-14 and formate carbon-14 uptake, using isomolar concentrations with the same specific activity, shows that very similar amounts of carbon-14 are taken up with both precursors (Table 1). Similar findings have been reported by other workers[5]. Since adenine carbon-14 and formate carbon-14 are in great excess in the medium (0·77 m.mole/ml.), if adenine carbon-14 was freely utilized for deoxyribonucleic acid guanine biosynthesis, one might expect a higher degree of labelling of deoxyribonucleic acid with adenine than with formate. The results in Table 1 indicate that in human bone marrow cells *in vitro* the utilization of adenine for guanine biosynthesis probably occurs very imperfectly. The slightly lower total grains per 100 cells in adenine carbon-14 cultures (by about 17 per cent) are probably due to the removal of some purines by the hydrolysis with *N* hydrochloric acid at 60° C. for 6 min.[6], which was necessary to remove nuclear ribonucleic acids. The latter are labelled to a similar extent as deoxyribonucleic acid[1].

Table 1. Comparison of Adenine Carbon-14 and Formate Carbon-14 Uptake into Deoxyribonucleic Acid in 16–21 hr. Cultures using Isomolar Media of same Specific Activity

Adenine carbon-14 (%+) −ve	Adenine carbon-14 Grains	Formate carbon-14 (%+) −ve	Formate carbon-14 Grains
58	25	62	45
64	50	55	40
56	40	73	50
52	40	65	50
66	50	53	45
50	50	74	50
58 ± 5	43 ± 8	64 ± 7	47 ± 4
Total grains/100 cells	2,494	Total grains/100 cells	3,008

There is some controversy in the literature as to the effect of radiation on the incorporation of different precursors of deoxyribonucleic acid. Harrington and Lavik[7] found that in rat thymus radiation depressed formate carbon-14 uptake into deoxyribonucleic acid, leaving adenine carbon-14 incorporation unaffected. Although other workers[8] did not confirm these results, Passoneau and Totter[9] found in chick embryos results similar to those reported by Harrington and Lavik. The suitability of the above experimental systems as regards normal biosynthesis has been queried[10] and therefore the problem has been investigated in human bone marrow cultures at the cellular level. The results in six experiments indicated that in this system both adenine carbon-14 and formate carbon-14 uptake were depressed to about the same extent by 1,000 rads of X-rays *in vitro*: adenine carbon-14 uptake by 68 ± 13 per cent, and formate carbon-14 uptake by 66 ± 17 per cent.

Comparison of the timing of the deoxyribonucleic acid synthetic period in the cell cycle using adenine carbon-14 or formate carbon-14 indicated that formate carbon-14 is utilized simultaneously with adenine for deoxyribonucleic acid biosynthesis during the approximately 12-hr. synthetic period. No indication was found for the existence of a pre-synthetic accumulation of low molecular weight precursors using formate carbon-14.

These results fail to indicate that irradiation would interfere with any particular step in synthesis of deoxyribonucleic acid. Inhibition appears to be the result of interference with some other mechanisms in the cell than the actual process of synthesis of deoxyribonucleic acid, as has been indicated by other studies[11,12].

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Relation between Ribonuclease Activity and Ribonucleic Acid Content

The penetration of ribonuclease into ascites tumour and bone marrow cells has been described elsewhere[1]. It was shown that the biochemical effects induced in different types of cells by the enzyme seems to depend on the original level of ribonuclease in these cells. Landschütz ascites tumour cells, which are very poor in ribonuclease as compared with bone marrow cells, are very much more sensitive to its action[1,2]. These observations, together with the fact that the bone marrow cells, although they are richer in ribonuclease, are poorer in ribonucleic acid, have led

us to determine the normal level of ribonuclease in different organs of normal animals, and to attempt to find if there is a relationship between the content of ribonuclease and that of ribonucleic acid in normal and cancerous tissues.

In the present work, organs are withdrawn immediately after killing the animals (mice or rats). They are thoroughly washed and minced in iced physiological serum, then homogenized. An aliquot is withdrawn for determinations of ribonucleic acid, deoxyribonucleic acid and protein, while another is extracted with 0·15 *N* sulphuric acid (final concentration) for 1 hr.

The first aliquot is extracted with 5 per cent perchloric acid and washed 10–12 times with ethanol/ether mixtures of increasing ether content. The dried sediment is hydrolysed in 10 per cent trichloracetic acid following the procedure of Schneider[3] or hydrolysed following the procedure of Schmidt–Tannhauser[4] using 0·1 *N* (instead of normal) sodium hydroxide. Content of ribonucleic acid and of deoxyribonucleic acid are then estimated by the orcinol and diphenylamine methods respectively or by measurement of ultra-violet absorption. Both procedures lead to similar results. The protein determinations are carried on the insoluble residues using the method of Lowry *et al.*[5].

On the second aliquot, protein determinations are also performed, and the centrifuged extract is used for determinations of ribonuclease. A sample of this extract is incubated at 25° C. in presence of polymerized yeast ribonucleic acid, prepared by the method of Kay *et al.*[6] and dissolved in 0·2 *M* acetate buffer of *p*H 5.

Samples are taken at 2, 15 and 30 min. and precipitated with an iced ethanol/perchloric acid mixture. After 15 min., the suspension is centrifuged, and the supernatant is analysed for nucleotide content by means of a Beckman ultra-violet spectrophotometer. The enzyme activity is estimated from the slope of the straight line obtained. This activity measurement includes, evidently, all the nucleolytic enzymes dealing with depolymerization of ribonucleic acid. Fig. 1 shows the results obtained in three different experiments (performed respectively on three mice two mice and one rat). The ribonuclease/protein and ribonucleic acid/protein ratios for eleven organs are indicated, with their respective standard errors.

The results show that there is a significant correlation between content of ribonuclease and of ribonucleic acid for normal organs (significance of the regression line: $t_9 = 5{\cdot}35$, $P \ll 0{\cdot}001$). This relationship is an indication of the possible importance of the nucleolytic enzyme content for cellular metabolism, as already suggested by Roth[7]. The importance of the nucleolytic enzyme content in ribonucleic acid metabolism is now being tested with radioactive purine and pyrimidine precursors. According to the hypothesis of Brachet[8] and Caspersson[9] of a relation between ribonucleic acid and protein synthesis, it is conceivable that the nucleolytic enzyme-level in different tissues might be the pacemaker for the growth and the differentiation of the cells. In this respect, it should be noted that the mouse Landschütz ascites tumour occupies a very peculiar place in the graph: experiments are in progress to determine whether this is particular to that type of tumour or is a general characteristic of cancer tissues. Differences between the level of activity of enzymes of normal and cancerous tissues have recently been noted by Lewin[10] for xanthinoxidase and by de Lamirande[11] for different purine metabolizing enzymes.

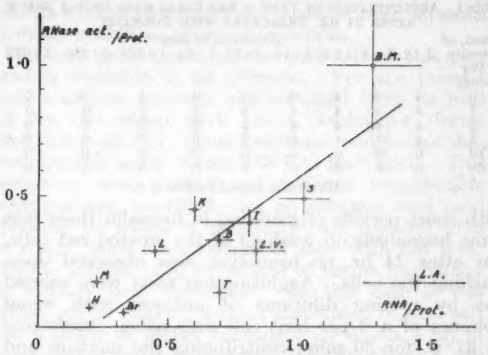

Fig. 1. Variation of ribonuclease/protein ratio versus ribonucleic acid/protein ratio for different tissues of the mouse or the rat. *H*, heart; *M*, muscle; *B*, brain; *L*, lung; *T*, testis; *B*, blood; *K*, kidney; *L.V.*, liver; *I*, intestine; *S*, spleen; *B.M.*, bone marrow; *L.A.*, Landshütz ascites

Note added in proof. A recent publication by S. Brody (*Biochim. Biophys. Acta*, 24, 502; 1957) shows the existence of a similar correlation between ribonucleic acid and ribonuclease activities during the development of the human placenta.

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Surface Alteration and the Agglutinability of Red Cells

In the course of a study of the effects of formalin on red cells it was noted that formalin was capable of completely inhibiting the agglutinability of red cells by antisera without destroying the antigens of the cells.

Initially, the effect of concentration of formalin and length of treatment on the stability of red cells was examined. Various dilutions of formalin were made up in buffered saline and the solutions were adjusted to *p*H 7·3. Five per cent suspensions of washed human red cells were made in the formalin dilutions and stood for varying lengths of time at 25° C. The mixtures were centrifuged, and the formalin-treated red cells were washed four times with buffered saline (*p*H 7·3). It was observed that

Table 1. Agglutination of Type *A* Red Cells with Anti-*A* Serum after 24 hr. Treatment with Formalin

Concn. of formalin (Per cent)	Dilutions of sera 1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
0	4	4	4	4	4	4	4	3	0
1	4	4	4	4	4	3	2	0	0
2	4	4	4	4	4	3	0	0	0
5	4	4	4	3	2	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0

Maximum agglutination = 4.

with short periods of standing in formalin there was some hæmolysis on washing of the treated red cells, but after 24 hr. no hæmolysis was observed upon washing the cells. Agglutination tests were carried out by mixing dilutions of antisera with equal volumes of a 2 per cent cell suspension, incubating at 37° C. for 30 min., centrifuging the mixture and observing for agglutination by gently agitating the tube. The agglutinin titres observed with anti-*A* sera and type *A* red cells treated with various concentrations of formalin for 24 hr. at 25° C. are given in Table 1. It is observed that the lower concentrations of formalin decrease the agglutinability of the red cells while the higher concentrations suppress it. In view of these results treatment of red cells with 20 per cent formalin for 24 hr. at 25° C. was adopted as the standard treatment procedure in the work to be discussed.

The Coombs test was negative with formalin-treated red cells, as were attempts to effect agglutination by the addition of anti-rabbit globulin serum to the cells sensitized with Coombs serum or by the Coombs 'build up' technique[1]. Serum was absorbed by mixing one volume of packed red cells with one volume of serum at room temperature for 15 min. The results of an absorption experiment with type *A* red cells and anti-*A* serum are given in Table 2. It is observed that formalin-treated red cells removed the agglutinin. It was thought that formalin-treated red cells may in some way be removing the agglutinins non-specifically; however, this was ruled out by noting that type *B* formalin-treated red cells did not remove the agglutinins from anti-*A* sera (Table 2) and that type *A* formalin-treated red cells did not remove anti-*B* agglutinins. When the formalin-treated red cells that were used in the absorption experiment were thoroughly washed, mixed with an equal volume of buffered saline and heated at 56° C. for 15 min., the specific agglutinin was eluted.

Experiments were carried out with type *B*, *Rh* (*D*), and with periodate-treated cells[2] with identical results. Periodate ions render red cells panagglutinable and experiments were carried out with red cells treated with formalin before and after periodate treatment.

Table 2. Absorption of Anti-*A* Serum by Normal and Formalin-treated Red Cells

	Dilutions of sera 1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
1. Unabsorbed sera	4	4	4	4	4	4	3	0
2. Serum absorbed with formalin-treated *A* cells	0	0	0	0	0	0	0	0
3. Serum absorbed with normal *A* cells	1	0	0	0	0	0	0	0
4. Serum absorbed with formalin-treated *B* cells	4	4	4	4	4	3	2	0

These results indicate that formalin acts in some manner on the surface of the red cell so as to inhibit the ability of the cells to be agglutinated, without having any apparent effect on the antigens that have been studied thus far. The mode of action of formalin in causing this effect is not known at present. The results suggest that in studying substances that are being tested for their effect on the antigens of red cells it is not sufficient to see whether or not such substances inhibit the agglutination of red cells. The destruction of the ability of the red cells to be agglutinated by their specific antisera may be due, as is the case here, to an alteration of the surface of the cell even though the antigen is not affected.

Recently a number of papers[3–5] have appeared describing red cells which are type *A* but which are weakly agglutinable or not agglutinated by anti-*A* sera. Red cells behaving in this manner have been assigned to a number of different new sub-groups of *A*, and the occurrence of such types of red cells is thought to be genetically controlled by a modifying gene. In one instance this property was noted to develop in the course of a disease. In view of the observations noted with formalin-treated red cells it is suggested that in some cases this behaviour of red cells may not be due to genetic differences but that this property may be acquired due to some alteration to the red cell surface *in vivo*. It would appear possible that changes in the surface of the red cells *in vivo* may alter the reaction with antisera. It has been noted that the surfaces of red cells treated with formalin when observed under the electron microscope[6] resemble those of cells from patients with diseases such as acquired hæmolytic anæmia in which changes in the surface of the red cells are thought to occur. It would be interesting to test the agglutinability of an individual's red cells over a period of time in health and during the course of various diseases to see if any change occurs. The detection of such changes, if they do indeed occur, may be of value in the diagnosis of and following the course of certain diseases.

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Intracellular Distribution of Catecholamines in the Brain

A survey of animal tissues carried out in this Laboratory[1] has shown that 3-hydroxytyramine is found more consistently and in higher concentration in the brain than in a number of other tissues. We have now studied the intracellular distribution of adrenaline, noradrenaline and 3-hydroxytyramine in the brain stem of the rabbit.

The tissue, homogenized in a solution of 10 per cent sucrose and 0·1 per cent sodium ethylenediamine-

Table 1. CATECHOLAMINES IN THE BRAIN STEM OF THE RABBIT

	Adrenaline (μgm./kgm.)	Noradrenaline (μgm./kgm.)	Hydroxytyramine (μgm./kgm.)	Dihydroxyphenylalanine (μgm./kgm.)
Homogenate, acidified immediately	89	320	776	0 (< 15)
Homogenate, acidified later*	85	306	824	
Coarse fraction	8·2	28·5	74	
Mitochondria	35·8	144	305	
Microsomes	4·5	16·6	42	
Supernatant	36·6	114	394	

*Homogenate acidified later: a sample of the sucrose homogenate was kept at 0° until the fractionating operations were completed and was then acidified.

tetraacetate (*p*H 7), was separated into four fractions at 0°: (1) a coarse fraction, obtained by centrifuging in an angle head at 300*g* for 5 min.; (2) a mitochondrial fraction, obtained by centrifuging at 10,000*g* for 20 min.; (3) a microsome fraction, obtained by adjusting the supernatant to *p*H 5·5 and afterwards centrifuging at 10,000*g* for 15 min.; and (4) the final supernatant fraction. All fractions were extracted with 0·1 *N* hydrochloric acid (final concentration). From these extracts catechols were isolated by adsorption on columns of alumina, further fractionated by chromatography on cation exchange resins and estimated fluorimetrically, as outlined in previous publications[1,2].

A representative result is shown in Table 1. Catecholamines were about equally divided between mitochondrial and supernatant fractions; the smaller amounts found in the coarse and microsome fractions were probably due to their contamination with the other two fractions. The total of the four intracellular fractions tallies well with the amounts found in the unfractionated homogenate. It is interesting to note that the three catecholamines occur in similar proportions in the different fractions. Whereas Montagu[1] found 3,4-dihydroxyphenylalanine in human brain, measurable amounts were not encountered in our analyses.

In the experiments described the rabbits were injected with iproniazid 1 hr. before death (100 mgm./kgm., intraperitoneally). The enzymic breakdown of catecholamines during fractionation, which is considerable otherwise, is thereby effectively inhibited.

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Sodium Salt of the Directly Reacting Bile Pigment

THE composition of the bile pigment which shows direct van den Bergh reaction has been elucidated in recent studies[1-3]. This pigment is considered to be essentially a mixture of soluble salts of bilirubinyl-*bis*(β-D-glucosiduronic) and bilirubinyl-mono(β-D-glucosiduronic) acids. The preparation of the insoluble lead salt of the first of these acids has been reported in previous communications[3]. This precipitation renders possible a concentration of the pigment from aqueous alcoholic solutions of rough material.

Without decomposition, the lead salt of this pigment is insoluble in all solvents. For the present work a soluble pigment was obtained from its lead salt by conversion with cation exchanger (formaldehydic resin from phenolsulphonic and β-naphthalenesulphonic acids 'Katex *FN*') in Na+ cycle. This conversion was carried out without considerable decomposition, provided that no stronger acid, and especially no traces of alkalinity[4], are released from the resin. Such a conversion of salts with low solubility to soluble ones by means of cation exchanger has already been described[5]. In this case it was carried out by shaking a thick suspension of lead salt with a slurry of cation exchanger for about ½ hr. in an evacuated centrifuge tube. Usually about 1 ml. (= 0·4 gm.) of the resin is sufficient for 20 mgm. of bilirubin contained in the suspension. After removing the resin by centrifugation, the clear supernatant is quickly dried *in vacuo*.

The resulting amorphous material is collected in the form of dark-brown lamellæ, freely soluble in water, relatively soluble in methanol, less soluble in ethanol, insoluble in chloroform, ether and acetone. Colloidal particles of the lead salt which escaped conversion often become suspended owing to the high peptization properties of the pigment solution. These residues can be removed by precipitation or re-extraction with methanol. The resulting material gave by analysis 62 per cent pigments (bilirubin + biliverdin—55 per cent bilirubin), 28 per cent glucuronic acid, calculated on the weight basis as glucurone. Theoretically, the disodium salt of diglucuronide should yield 59·5 per cent pigment and 35·9 per cent glucuronic acid (on the above-mentioned basis)[4].

This product can be purified further by reversed phase chromatography as designed by Cole and coworkers[6] on columns arranged according to Billing[7] but on a larger scale (silicone-treated kieselguhr was generously given by Dr. G. H. Lathe of London). Instead of phosphate buffer in the system *B*[6] a 0·02-*M* acetate buffer of *p*H 5·6 was used in order to allow further precipitation of the lead salt from the methanolic eluate of a corresponding segment. Glucuronic acid was always detected although in quantities not identical with theoretical ones.

The assumption of a glucuronide character of this pigment is now supported by the recent biosynthetic experiments of Carbone and Grodsky[8], Lathe and Walker[9] and Schmid[10].

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Selenomethionine in Enzymatic Transmethylations

In the past, biological interest in selenium has been centred around its toxic role as the cause of 'alkali disease' and 'blind staggers'[1] and as a source of industrial poisoning[2]. However, recent developments suggest a more important role for this element. Thus, it has been shown that selenium is an essential trace element for the rat[3] and is stimulatory, if not essential, for the growth of certain plants[4]. While inorganic selenium compounds are active in these cases, there is evidence that these inorganic selenium compounds are converted biologically into organic compounds, including the selenium analogues of cysteine[5], cystine, methionine[6] and cystathionine[7]. The structure of the essential selenium compound or compounds, therefore, remains to be established.

These results have stimulated interest in the metabolic role of selenomethionine. This analogue has been shown to support exponential growth of a methionine-requiring *E. coli* mutant, growth continuing for as long as one hundred generations on a methionine-free medium containing selenomethionine. Furthermore, micro-organisms grown under these conditions are capable of adaptive enzyme formation[5,8]. These results are of particular significance in that they demonstrate that proteins in which methionine is replaced by its selenium analogue have retained their functional integrity.

In the light of these findings, it was considered of interest to investigate the ability of selenomethionine to replace methionine in a biological reaction in which the sulphur atom of this amino-acid is functionally involved, namely, transmethylation. As is well established, an adenosine triphosphate-dependent enzymatic activation resulting in the formation of S-adenosylmethionine is a prerequisite for the enzymatic transfer of the methyl group of methionine. S-adenosylmethionine can act as a methyl donor to a suitable methyl acceptor in the presence of specific methylpherases[9]. It may be recalled that an essential feature in the activation reaction is the conversion of the sulphur atom from a thioether to a sulphonium configuration.

When selenomethionine was incubated with methionine-activating enzyme prepared from rabbit liver[10] or yeast[11], it was utilized as well as or better than methionine. Fig. 1 shows the results of an experiment in which methionine and selenomethionine are compared as substrates for the yeast methionine-activating enzyme. In the presence of excess pyrophosphatase the reaction can be followed by measuring the amino-acid dependent mineralization of the three phosphates of adenosine triphosphate and/or the formation of an adenosyl compound which, because of its cationic nature, is not adsorbed on 'Dowex-1' Cl. It can be seen that, in fact, selenomethionine is a better substrate for the yeast-activating enzyme than the natural sulphur analogue.

To test the ability of Se-adenosylselenomethionine to serve as methyl donor, the adenosyl compound formed from selenomethionine was precipitated as the crystalline trireineckate derivative, converted to the sulphate salt and afterwards incubated with guanidoacetic acid in the presence of pig-liver creatine methylpherase[9]. It was found that 0·28 μmole of Se-adenosylselenomethionine supported formation of 0·21 μmole of creatine by transmethylation while a

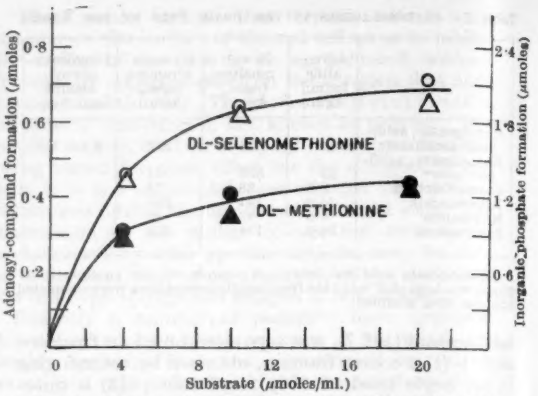

Fig. 1. Each vessel contained in a final volume of 0·5 ml.: *tris*(hydroxymethyl)aminomethane, *p*H 7·6, 75 μmoles; potassium chloride, 150 μmoles; magnesium chloride, 150 μmoles; adenosine triphosphate, neutralized with potassium hydroxide, 12 μmoles; reduced glutathione, neutralized with potassium hydroxide, 5 μmoles; substrate as indicated; an excess of yeast inorganic pyrophosphatase; 90 micrograms of methionine activating enzyme purified 250-fold from an extract of baker's yeast (ref. 11). Incubation was for 30 min. at 37°. The reaction was terminated by addition of perchloric acid and aliquots of the protein-free supernatant were used for determination of the inorganic phosphate (triangles) and adenosyl compound (circles) (ref. 10). A control was run without added substrate and the control value subtracted from the experimental. The stoichiometry of the reaction requires the mineralization of three moles of phosphate for each mole of adenosyl compound formed

control of 0·32 μmole of authentic S-adenosylmethionine gave a quantitative yield of creatine.

The ability of inorganic selenium compounds to function as methyl acceptors in fungi and related species has been demonstrated by the studies of Challenger and his school[12]. The experiments reported here emphasize the ability of selenomethionine to replace its natural sulphur analogue as a substrate in two enzymatic reactions involved in biological transmethylation. Although in one instance it has been found that selenomethionine competes with its sulphur analogue[13], it may be postulated on the basis of the present evidence that the ability of seleniferous compounds to replace their sulphur-containing analogues is rather widespread.

We wish to thank Dr. Dean Cowie for use of a manuscript prior to publication and for the gift of a sample of selenomethionine which was originally synthesized by Dr. Alex Schrift.

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Lactic Acid Formation and Carbon Dioxide Fixation

In an investigation, first into the composition of the internal atmosphere of successively lower regions of the plant body of *Equisetum limosum*, and secondly into the respiratory metabolism of the perennating rhizomes of this plant, a very interesting relationship between lactic acid formation and carbon dioxide fixation has emerged.

The plants studied grew in standing water, 1–1·5 m. deep with their perennating rhizomes extending in the bottom mud to a depth of up to 20 cm. This constituted a very markedly anaerobic environment. The internal atmosphere of the rhizome was rich in carbon dioxide and low in oxygen, the carbon dioxide concentration ranging between 5 and 8 per cent and the oxygen concentration between 2 and 8 per cent.

The rate of respiration of internodes of rhizome tissue was studied over a three-day period in various concentrations of carbon dioxide with an oxygen tension generally fixed at 5 per cent. Respiration was also studied in air and nitrogen. After the three-day period of respiration, the organic acids, α-keto acids and alcohol-soluble sugars were extracted from the tissue, separated chromatographically and estimated.

In Table 1 the amounts of lactic acid present in tissue allowed to respire in the dark at 25° C. under various gaseous conditions are given, together with the respiratory quotients obtained over the three-day respiratory period. It will be seen that a trace of lactic acid was present after respiration in a mixture of 2·5 per cent carbon dioxide and 5 per cent oxygen. No lactic acid was found in material allowed to respire in gas mixtures containing 3–12 per cent carbon dioxide with 5 per cent oxygen, nor in a mixture of 20 per cent oxygen and 3 per cent carbon dioxide.

The presence of a lactic dehydrogenase was demonstrated in a particulate suspension prepared according to the method of Davis[1].

The low respiratory quotients given by tissues in the presence of carbon dioxide suggested that carbon dioxide fixation may well have been occurring. This was investigated by making an autoradiograph of a chromatogram of the organic acids extracted from tissue that had been allowed to respire for 12 hr. in a mixture of 5 per cent oxygen and 7 per cent carbon dioxide containing a very small fraction carbon-14 labelled carbon dioxide. The autoradiograph gave a clear indication of carbon dioxide fixation, as there was labelling in malic, citric and succinic acids and in two unknown acids, one of which was tentatively identified as β-hydroxy butyric acid.

Thus the presence of lactic acid has been demonstrated only in tissues where it seemed unlikely that carbon dioxide fixation had occurred.

Table 1. Respiratory Quotients and Lactic Acid Content

Atmosphere			Respiratory quotient			Lactic acid γ per gm. F.W.
O_2 (per cent)	Co_2 (per cent)	N_2 (per cent)	1st day	2nd day	3rd day	
5·0	2·0	93·0	0·385	1·28	0·759	0·0
5·0	2·5	92·5	—	0·36	1·25	9·4
5·0	5·0	90·0	—	1·28	0·759	0·0
5·0	12·0	83·0	0·097	0·068	0·41	0·0
20·0	3·0	77·0	1·18	0·616	0·404	0·0
Air			0·865	0·760	0·669	41·5
3·5	0·0	96·5	1·23	1·11	1·20	31·0
0·0	0·0	100·0	—	—	—	77·5
0·0	5·0	95·0	—	—	—	40·0

Carbon dioxide fixation, whether by the malic enzyme as demonstrated by Conn *et al.*[2] or by a modified Wood–Werkman reaction described by Wood[3] and Utter[4] depends upon the β-carboxylation of pyruvic acid. It may well be, therefore, that where carbon dioxide fixation occurs there is a competition for pyruvic acid, by the processes of lactic acid formation and carbon dioxide fixation. There is, however, a second possibility, for Ochoa *et al.*[5] have demonstrated a coupled process of lactic acid oxidation and carbon dioxide fixation in pigeon-liver extracts.

$$\text{Malate} + \text{TPNox.} \xrightleftharpoons[\text{Malic enz.}]{Mn^{++}} \text{Pyruvate} + CO_2 + \text{TPN red.}$$

$$\text{Pyruvate} + \text{TPN red.} \xrightleftharpoons[\text{Lactic dehyd.}]{} \text{Lactate} + \text{TPNox.}$$

$$\text{Sum.} \quad \text{Malate} \xrightleftharpoons{Mn^{++}\ TPN} \text{Lactate} + CO_2$$

Korkes *et al.*[6] have demonstrated an essentially similar DPN specific malic enzyme/lactic dehydrogenase system in *Lactobacillus arabinosus*.

In general ecology of such a plant as *Equisetum*, it would plainly be of value if it possessed a mechanism whereby the two processes of lactic acid formation and carbon dioxide fixation competed for pyruvic acid. It would be equally important if there existed a TPN- or DPN-linked dismutation between malic acid and pyruvic acid through the combined action of the malic enzyme and the lactic dehydrogenase system. The fixation of respiratory carbon dioxide conserves the carbon of the rhizome, maintaining the levels of the organic acids, and if, as suggested, the process is linked to lactic acid oxidation, it would prevent the build-up of that fermentation product.

This work, which was carried out in the Department of Botany, University of Liverpool, under the supervision of Mr. D. A. Coult, will be reported in full elsewhere. It is a pleasure to acknowledge my indebtedness to Mr. D. A. Coult and Prof. N. A. Burges for their interest in this work and to Dr. W. O. James of the Department of Botany, University of Oxford, for his interest and kindness in giving me the facilities of his laboratory in which to learn the necessary chromatographic techniques. I am grateful to the Department of Scientific and Industrial Research for financial assistance.

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Narcotic Activity of Optical Enantiomorphs of Methylpentynol

The optical resolution of *dl*-3-methylpent-1-yn-3-ol was achieved for the first time by one of us[1] some two years ago, and it seemed of interest to determine whether the narcotic activity of the optical antipodes differed, in spite of the contrary finding in the

barbituric acid series. The criterion of narcosis was abolition of the righting reflex in female mice.

Racemic methylpentynol and its (+)-enantiomorph were administered orally to groups of thirty-five mice at two dose-levels (506 and 338 mgm./kgm.) and the two results were compared 1 hr. after dosage. *dl*-Methylpentynol showed sixteen and three animals narcotized compared with seventeen and three for (+)-methylpentynol on the two doses. A somewhat impure sample of (−)-methylpentynol showed a slight diminution in activity in a group of fifteen mice, which was not significant in view of the above result.

A contemplated extension of the work to certain optically active esters of methylpentynol was therefore abandoned.

It is of interest to note that the *dl*-hydrogen phthalate, prepared in the course of the above work, was completely without effect, presumably owing to the very slow rate of hydrolysis *in vivo*.

We wish to thank Mrs. I. M. Weaver for the biological work involved.

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Table 1. Effect of Methylene Blue on the Body and Organ Weights of Adult Male and Female Mice

No. of animals in group			Body-weight	Spleen	Seminal vesicles	Testicles	Adrenals
Male	Control	10	29·5±0·6† (25·1)‡	260±22·0§	310±17·3	580±17·0	20±1·9
	Methylene blue	11	29·0±0·5 (23·5)	790±97·0	170±11·2	590±20·0	18±1·9
Female	Control	10	26·7±0·9 (20·6)	520±62·0	Uterus and ovaries 240±35·0		42±2·5
Female	Methylene blue	10	25·3±0·6 (19·5)	790±66·0	230±40·0		47±3·3

† Mean final weight in gm. ± S.E. of mean $\left(\sqrt{\frac{d^2}{n(n-1)}}\right)$

‡ Mean initial weight in gm.

§ Mean weight in mgm. per 100 gm. of body weight ± S.E. of mean.

Table 2. Effect of Methylene Blue on Body and Organ Weights of Male Mice with an Initial Weight of 14 gm.

No. of animals in group		Body-weight	Spleen	Seminal vesicles	Testicles
Control	10	26·2±0·8† (14·4‡	323±30·0§	271±15·0	606±15·0
Methylene blue	11	18·3±1·2 (14·0)	3,924±224·0	93±22·0	650±49·0

†, ‡, §, As in Table 1.

In both sexes the body-weight was not affected when the initial weight was about 20 gm., but the spleen became very heavy. This is more evident in the male, in which this organ is normally lighter than in the female (Table 1).

There was a reduction in the growth-rate of the males with an initial weight of 14 gm., but the effect of the drug on the spleen was the same (Table 2).

In the males of both groups there was a reduction in the weight of the seminal vesicles (Tables 1 and 2). It is obvious from the results of the heavier group that this effect is not related to any inhibition of growth.

These effects seem to be restricted to the mouse. We were unable to detect them in the rat or the guinea pig even though there is a distinct change in the colour of the spleen.

The animals were active and healthy during the experiment. There were no indications of infection due to the blockage of the spleen.

We have not studied systematically the vaginal smears of the female group.

In castrated male mice methylene blue does not change the effect of the testosterone propionate on the seminal vesicles. These results suggest further study of the action of the drug on the testicular and hypophyseal functions of the mouse before any definite conclusion can be reached.

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Effects of Methylene Blue added to a Low Fat Diet in the Mouse

Dam and co-workers[1] have studied the effect of methylene blue added to various diets in the rat, and suggested that the drug can perform some of the functions of vitamin E. Dealing with young rats, they described an inhibition of growth; but no organ appeared to be especially affected.

We studied, in the mouse, the effect of the addition of methylene blue to a synthetic diet with a low fat content.

The composition of the diet was: complex-B free casein, 20 per cent; sucrose, 74·5 per cent; salt mixture, 5 per cent[2]; vitamins[3] and 0·5 per cent arachis oil. The α-tocopherol content was 150 mgm. per kgm. of diet. The methylene blue concentration was 0·126 per cent. The food was stored at 0° C.

The mice were from the colony at the Faculdade de Medicina de São Paulo. Both food and water were changed daily and given *ad libitum*. The animals were killed after 30 days. They were immediately dissected and the organs weighed on a torsion balance to the nearest 0·2 mgm. Groups of ten or more animals were used.

Occurrence of Periodic Acid–Schiff Positive Material in the Pituitary of the Parrot Fish, *Pseudoscarus guacamaia*

During the course of investigations into the histochemistry of fish pituitaries, the distribution of periodic acid–Schiff positive material[1] was noted in the parrot fish, *Pseudoscarus guacamaia*. Whereas in mammalian pituitaries periodic acid–Schiff positive material is associated only with basophils (aniline-blue positive after Heidenhain's 'Azan' procedure), namely, the gonadotrophs and thryotrophs[2], in *Pseudoscarus* the mid-glandular region of the adeno-hypophysis has two types of acidophils, one of which is strongly and uniformly periodic acid–Schiff positive and the other negative. This large polygonaly shaped periodic acid–Schiff positive acidophil of *Pseudoscarus* stains a deep orange after the Gomori aldehyde–fuchsin orange *G* method for the demonstration of neurosecretory material and is carminophilic after treatment with Heidenhain's 'Azan' stain. In addition to this type of cell, two types of basophils are present in the mid-glandular region which are periodic acid–Schiff positive as in mammals and other teleost fish. Furthermore, although some of the periodic acid–Schiff positive basophils stained selectively after aldehyde–fuchsin as in other teleosts[3], the periodic acid–Schiff positive acidophil gave a negative aldehyde–fuchsin reaction. It would appear, then, that in this fish, unlike mammals, a carbohydrate-containing hormone is possibly produced by cells which are 'acidophilic' after application of the conventional staining procedures.

Neurosecretory material in the neurohypophysis of *Pseudoscarus* gives a very positive reaction after aldehyde–fuchsin treatment. However, this neurosecretory material is not periodic acid–Schiff positive, This appears to conform with observations made on the neurohypophysis of other species of fish in which there is little or no carbohydrate-containing material that can be identified with the neurosecretion. Schiebler[4], however, reports periodic acid–Schiff positive material having the same localization as Gomori neurosecretory substance in the pike (*Esox lucius*), and has suggested that neurosecretion is probably a complex of glycolipoprotein. Observations made on the neurosecretory substance of *Pseudoscarus* and some other teleosts have given results which are more in accord with those of Howe and Pearse[5], who regard the neurosecretory substance as not containing lipid or carbohydrate material and being protein or polypeptide in character.

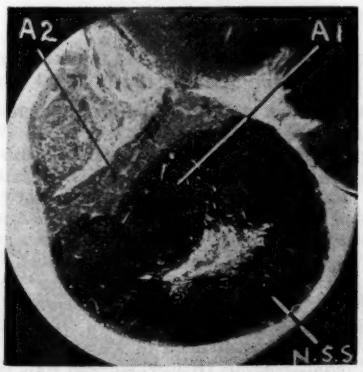

Fig. 1. Longitudinal section of the pituitary of *Pseudoscarus* (× *c.* 215) after staining in orange *G* and aldehyde–fuchsin showing dark orange acidophils, *A*1; yellow acidophils, *A*2; and neurosecretory substance, N.S.S.

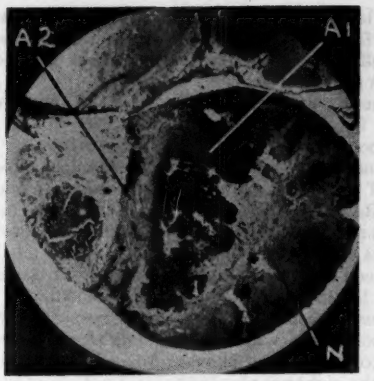

Fig. 2. An adjacent section to that of Fig. 1 after periodic acid–Schiff treatment showing that only the *A*1 acidophils are positive. *N*, neurohypophysis

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Soil Transmission of Beet Ringspot Virus to Peach (*Prunus persica*)

Although few plant viruses are known to be soil-borne, recent studies have shown that such viruses are present in many localities in eastern Scotland[1–3], and it was suggested that they are probably much more generally distributed than has hitherto been suspected. The soil-borne viruses found in Scotland appear to have a very wide host-range, and one of them, beet ringspot virus, has been isolated from many species of herbaceous plants, including sugar beet, potato, turnip, wheat, oat, strawberry and many weeds[3]. The results reported below show that this virus is also soil-borne to peach, a woody species, and that the virus can be readily transmitted by mechanical inoculation from peach to herbaceous plants.

In April 1956, twenty-five peach seedlings were planted in pots of soil which was collected from a field where beet ringspot virus occurred: the pots were kept in an insect-free glasshouse. Symptoms first appeared on seven plants in April 1957, when the dormant buds started to grow. However, one out of fifteen seedlings planted in similar soil in April 1957 showed symptoms within four weeks. Usually only a proportion of the buds on each diseased plant produced symptom-bearing leaves. These leaves had yellow blotches centred on the leaf midrib or lateral veins and often extending along them. Circular translucent areas also appeared in the laminas of

some leaves as they unfolded and these later broke away from the expanding leaf blades, became brown and fell out, leaving 'shot-holes'. Most of the diseased shoots grew only slowly.

Viruses, afterwards identified as beet ringspot virus by plant-protection tests in White Burley tobacco and by serological tests[3], were readily isolated from each diseased tree by mechanical inoculation of leaf extracts to *Chenopodium amaranticolor* Coste and Reyn., *Petunia hybrida* Vilm. and cucumber plants: the symptoms in these hosts were typical of beet ringspot virus. The numbers of local lesions produced by leaf extracts from different peach plants were 100–212 and 27–160 per inoculated leaf of *C. amaranticolor* and *P. hybrida* respectively. Beet ringspot virus was isolated only from leaves with symptoms: no virus was detected by inoculations from the eighteen plants that did not show symptoms or from control plants grown for the same period in steam-sterilized potting compost.

The symptoms in peach seem very like those caused by peach yellow bud mosaic virus in California[4]. This virus has also been transmitted by mechanical inoculation to plants of other species[5], and there is evidence that it also is soil-borne[6]. It therefore seems possible that beet ringspot and peach yellow bud mosaic are the same or closely related viruses.

Tomato black ring[7] and potato bouquet[8] are two other viruses which seemed to have properties similar to those of beet ringspot virus, and experiments have shown that there is a relationship between them. As these viruses have been found in England, Germany and Scotland, respectively, there is now good evidence that viruses of this type are fairly widely distributed.

This is thought to be the first record for western Europe of the natural mode of transmission of a virus in a fruit-tree species.

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Blindness in Early Summer Cauliflower

Wiebosch *et al.*[1] distinguished two forms of blindness in cauliflowers, namely, common blindness, where there is a sudden transition from normal development to complete blindness, and 'whiptail' (not due to molybdenum deficiency), where the leaves are malformed and small swollen 'stem organs' are produced in the centre of the plant. These workers suggested that both forms of blindness may be caused by a period of low temperature during the early stages of growth. A similar suggestion has been made by Smith[2]. Recently, Mounsey-Wood[3] found that blindness was associated with frost during the early growth of the crop, and suggested that low temperature when the seedlings were at a certain stage of development was likely to cause blindness.

Table 1

Period of low temperature treatment	Mean No. of leaves initiated before low temperature treatment	Effect of treatment	
		Percentage of plants with common blindness	Percentage of plants with partial blindness*
Feb. 8–22	3·2 ± 0·4	6·7	10·0
Feb. 22–March 8	4·8 ± 0·8	6·7	20·0
March 8–22†	7·3 ± 0·8	16·7	43·4
March 22–April 5	10·8 ± 0·8	6·7	6·7
Control (no low temperature)	—	0	3·3

* Termed 'whiptail' by Wiebosch *et al.* (ref. 1).
† The percentage of plants with blindness resulting from this treatment was significantly greater ($P < 0.01$) than that from the other treatments.

Evidence supporting this hypothesis has now been obtained at this Station.

Seed of the cauliflower variety Finneys 110, which is not normally susceptible to blindness, was sown on January 24. At different stages of growth, batches of thirty young plants were subjected to a temperature of 33 ± 2° F. for a period of fourteen days in a refrigerated cabinet which was illuminated artificially at an intensity of approximately 200 ft.-candles for the natural day-length. Except during the cold treatment period the plants were grown under conditions where the temperature did not fall below 45° F., until they were planted in the field on April 9. As a precaution, the plants were watered with sodium molybdate solution to prevent blindness from being caused by a deficiency of molybdenum[4].

The results obtained under the conditions of this experiment indicate that plants of this variety were particularly sensitive to a period of low temperature at a stage of development when approximately seven leaves had been initiated, as revealed by apical dissection.

Low temperature treatment before or after that stage caused blindness to a lesser extent.

Further work on this subject is proceeding, and a detailed account will be published elsewhere.

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Isolation of *Leptotrichia buccalis* and *Fusobacterium* Species from Oral Material

Considerable difficulty has been experienced by many workers in distinguishing between strains of *Leptotrichia buccalis* (Trevisan) and species of *Fusobacterium* (Knorr).

Bøe and Thjøtta[1] suggested that many of the organisms described by Spaulding and Rettger[2], Hine and Berry[3] and other workers as members of the genus *Fusobacterium* were in fact strains of *Leptotrichia*. These workers also cite Nieber[4] as having difficulty in separating strains of *Leptotrichia* from *Fusobacterium* species. The work of Jackins and Barker[5] on the metabolism of *F. nucleatum* (Knorr) and *F. plauti-vincenti* (Knorr) showed that these two organisms, although placed in the same genus, differ considerably in their metabolism and their Gram-staining reaction. This latter organism, which is

called *F. dentium* by Hine and Berry, is believed by Bøe and Thjøtta to be identical with, or closely related to, *Leptotrichia buccalis* (Trevisan). This view is also held by Hamilton and Zahler[6].

Work carried out in this laboratory has shown that it is possible to distinguish between strains of *Leptotrichia* and *Fusobacterium* by their sensitivity to dyes and antibiotics. Use has been made of this observation in devising selective media for the isolation of these organisms from the mouth.

Experiments were carried out on a number of dyes to test their selectivity. The dyes were added to a basal medium containing: Proteose peptone ('Difco'), 1 per cent; yeast extract ('Oxoid'), 0·1 per cent; 'Lab Lemco', 0·3 per cent; glucose, 0·5 per cent; soluble starch ('Analar'), 0·2 per cent; sodium nitrate, 0·1 per cent; cysteine hydrochloride, 0·05 per cent; and disodium hydrogen phosphate, 0·5 per cent. The constituents were dissolved in distilled water and the medium adjusted to *p*H 7·6. All experiments were carried out in McIntosh and Fildes jars filled with an atmosphere of hydrogen containing 10 per cent carbon dioxide, and incubated at 37° C.

The dye ethyl violet (Gurr's 'Michrome' brand), in the presence of a number of antibiotics, was found to be selective for isolating strains of *Leptotrichia* and *Fusobacterium* from the mouth. The concentration of dye used was one part in fifteen thousand to which the addition of either 15γ/ml. neomycin sulphate, 20 γ/ml. streptomycin sulphate or 0·001 mgm./ml. of bacitracin was found to be equally effective. The dye and the antibiotic were added aseptically to the medium immediately before use. Increasing the concentration of bacitracin to 0·1 mgm./ml. resulted in pure growth of *Fusobacterium* (Knorr); strains of *Leptotrichia* were inhibited. It was possible to isolate solely strains of *Leptotrichia buccalis* (Trevisan) by adding to the dye-containing medium 0·05 mgm./ml. of sulphathiazole. Lower concentrations of sulphathiazole permitted the isolation of both *Fusobacterium* and *Leptotrichia* species.

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A New Species of Coccidium (*Eimeria rissae* n.sp. Eimeriidae, *Sporozoa*) from the Kittiwake, *Rissa tridactyla tridactyla* (L.)

Eimeria rissae n.sp. was obtained from the small intestine of a kittiwake which had been sent to us as a representative of a number of sick and dying kittiwakes from the coast of Wales.

Post mortem examination revealed that, in addition to the following parasites, *Seuratia shipleyi*, *Prosthorhynchus* (?) *linearis* and some immature echinostomes which were present in small numbers, an extremely large number of unsporulated oocysts was found in the duodenum. In view of the number of oocysts and the concomitant evidence of enteritis, death was ascribed to coccidiosis. So far as can be ascertained, no previous record of coccidia in the kittiwake has been made, and since the present species could not be identified with that of coccidia from other hosts we propose to recognize it as a new species, and to name it *Eimeria rissae*.

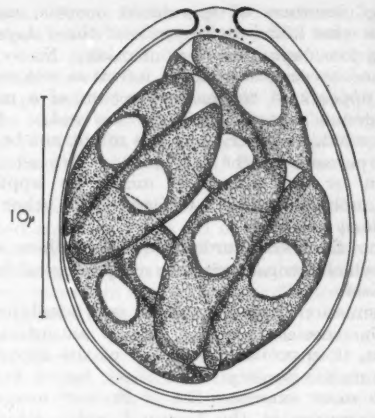

Fig. 1. Oocysts of *Eimeria rissae*. Lateral view of sporocysts, the sporocystic residual body omitted (camera lucida drawing)

The description of the oocyst is as follows. Slightly ovoid in shape with a distinct micropyle at the narrower end (2μ in diameter); oocyst wall consists of an outer thick wall (0·6μ in thickness) and an inner thin wall. The wall is distinctly thickened around the micropyle. The colour of the oocyst is very faintly yellow. Mean size, 13·6μ × 19·07μ; range, 12·1–15·4μ × 17·6–22μ. Sporulation time at room temperature (about 22° C.) is two days. Sporozoites lie side by side with a relatively large vacuole centrally placed. A large sporocystic residual body is present, roughly crescentic in shape and lies at the pole of the sporocyst filling half the diameter of the sporocyst when this is viewed end-on. No oocystic residual body is present, but numerous polar granules occur. These vary in number, sometimes as few as three large granules are present, and frequently up to twenty small granules are seen.

An attempt was made to transmit the infection to domestic chickens. Four week-old chickens were

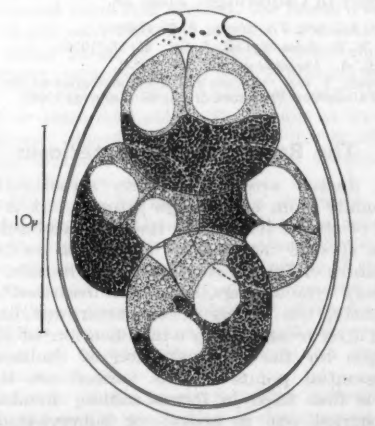

Fig. 2. Oocyst of *Eimeria rissae*. End-on view of sporocysts to show the marked sporocystic residual body (camera lucida drawing)

fed large numbers of sporulated oocysts, and the chickens were killed at intervals of three days commencing five days after the infection. No evidence was found to suggest that an infection was created.

This appears to be the first record of a member of the genus *Eimeria* from the kittiwake. It was kept in mind, however, that this might not be primarily a parasite of the kittiwake. Two sources of infection or contamination might be applicable, namely, acquisition from fish and from other birds, particularly sea-birds.

Of the *Eimeria* recorded from fish, there are no species which compare with the morphological features of *E. rissae*.

Transmission from other birds is a possibility, but since the species failed to set up an infection in chickens, it is probably not one of the *Eimeria* sp. from domestic poultry. The check list of Pellerdy[1] and the more extensive list of Becker[2] mention no *Eimeria* species in the family Laridae other than *Eimeria meservi* in Forster's Tern (*Sterna forsteri*), while in other families of sea birds *E. urnula* has been recorded in the cormorant (*Phalocrocorax carbo lugubris*)[3] and *E. roscoviensis* in the shag (*P. aristotelis aristotelis*)[4]. None of these has been recorded as occurring in birds in Britain, and, furthermore, with the exception of *E. urnula*, none agrees in size with *E. rissae*. Hoare[3] gives a range of 17·6–23·2μ × 12·8–13·6μ for *E. urnula*, but the shape of the oocyst and the character of the sporocysts differ from those of *E. rissae*.

We are of the opinion that sea-birds have been neglected from the point of view of coccidial infection. This is evident from perusal of the check list of Becker[2], where only three species are recorded from sea-fowl compared with the extensive records in mammals and other vertebrates. A more extensive and intensive study would, no doubt, reveal many hitherto unrecognized species.

We acknowledge financial assistance from the administrators of the H. E. Durham Fund, King's College, Cambridge, for this work, which is part of a wider survey of disease in the wild fauna of Great Britain.

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The Rabbit Ductus Arteriosus

The ductus arteriosus differs structurally and functionally from other large arteries. It is almost devoid of elastic tissue, and its smooth muscle fibres have a specific disposition[1,2]. In the rabbit, fine nerve fibres ending in relation to the muscle, as well as sensory type endings, have been described[3].

Recently, the rabbit ductus arteriosus has been studied after treatment by a modification[4] of Koelle's[5] technique for the demonstration of cholinesterase. The essential points of this variant are that the tissue is first fixed in formol-saline; incubation is then carried out in acetyl- or butyryl-thiocholine substrates which contain a high concentration of sodium sulphate, and are also buffered to an acid *p*H.

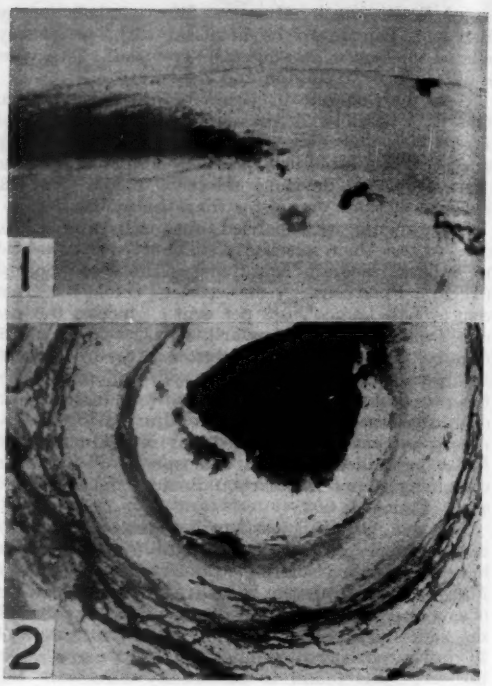

Fig. 1. 1, Longitudinal section of the junctional region between ductus arteriosus (on right) and aorta (left), showing the strongly positive cholinesterase reaction of aortic smooth muscle. The endothelial surface is along the upper edge of the section (× 83). 2, Transverse section (200μ) of ductus. A blood clot lies in the lumen. Cholinesterase-positive nerve fibres form a net in the adventitial zone of the wall, and some extend into the outer muscle layer (× 95)

Thick frozen sections and whole-thickness preparations were examined. It was found that the smooth muscle of the ductus differs histochemically from that of the pulmonary trunk and aorta. When incubated in a substrate of *p*H 5·6 it gives a negative reaction for cholinesterase, while that of the other two vessels is strongly positive. This contrast is especially marked in sections cut along the length of the ductus; at its junction with each of the other large trunks a well-defined boundary between the negative and positive muscle can be observed (Fig. 1,1).

Sections show a rich plexiform network of nerve fibres lying in the adventitial zone of the ductus wall (Fig. 1,2). A few small fibres penetrate the outer part of the muscle layer, and appear to end by branching. It is, however, difficult to be certain that this appearance is due to true nerve endings, and not simply to parts of the nervous network lying within the muscle layer.

Whole-thickness preparations of the ductus wall incubated as above and viewed from the endothelial surface show a network of nerve fibres with no obvious discrete endings. These fibres, although lying in the outer parts of the ductus wall, can be readily seen through its thickness on account of the negative cholinesterase reaction of its muscle.

These preliminary findings indicate that most of the ductus muscle is not in intimate contact with nervous elements. The negative cholinesterase reaction of this muscle, in contrast to the positive reaction in

that of the other vessels, readily demonstrates the extent of the ductus tissue. This histochemical differentiation is another distinctive property of the ductus, which is already known to differ in structure and function from other large arteries.

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Rearing of *Simulium damnosum* Theobald (Diptera, Simuliidae) in the Laboratory

Although adults of *S. damnosum* have been reared from larvæ, rearing from eggs does not appear to have been recorded. Hartley[1], however, was successful in rearing *S. venustum* adults from eggs. In view of the importance of *S. damnosum* as the main vector of onchocerciasis in Ghana and elsewhere, and the recommendation by the World Health Organization Expert Committee on Onchocerciasis[2] that the rearing of *Simulium* in captivity should be studied, it was felt that attempts should be made, when opportunity occurred, to rear *S. damnosum* in the laboratory. This communication describes the apparatus and method by which *S. damnosum* adults have been successfully reared from eggs.

The apparatus consisted of a trough of corrugated asbestos roofing material, inclined at an angle of 20°, in an aquarium tank containing three gallons of river water which was circulated via the trough by means of a water-circulating pump delivering approximately 60 gall. per hr. at an estimated velocity of 3·8 ft. per sec. Aeration was produced by maintaining the water-level 2 in. below the lower end of the trough to form a miniature waterfall, the inflow pipe being placed near this aerated water. Further aeration was obtained by piercing the polythene outflow pipe 1 ft. from the outlet with a suitably inclined M.R.C. type transfusion needle causing a stream of air to be drawn in.

In June (9 a.m.) a mass of some 10,000 eggs, apparently laid by many females in the manner described by Crisp[3] and Muirhead-Thomson[4], on submerged grasses, was obtained from Senchi rapids in the River Volta. 3 hr. later, by which time some eggs were already hatching, the grasses were placed in the trough and the water circulated. The eggs continued to hatch during the following day, comparing favourably with the hatching time of 36 hr. observed by Crisp[3]. Wanson and Henrard[5] state that in Leopoldville the eggs hatch within 4 hr. of deposition.

As the larvæ grew, the river water became clearer owing to the filtering out of plankton and suspended matter: at increasingly frequent intervals ½ gallon of water was removed from the tank and replaced by river water which had been concentrated approximately five hundred times by filtering through a fine plankton net. After 7 days many of the larger larvæ migrated up to 15 in. into the outflow pipe. Possible reasons for this migration were increased current velocity or greater depth of water (9 mm.).

Eight pupæ were formed, all in the outflow pipe, 14–17 days from hatching, the pupal stage lasting 2–3 days. Seven adults emerged successfully into a cage placed over the apparatus; but only three, all males, were collected, the remainder escaping. In field conditions in the Northern Territories of Ghana at a temperature of approximately 25° C., Crisp[3] found that the larval stage lasted 10–13 days and the pupal stage 4–5 days. In this experiment the temperature ranged from 21·1° C. to 31·1° C. with an average of 25·8° C.

On the nineteenth day all larvæ were found to be detached and dead; the *p*H of the water in the tank was now found to be 7·3 compared with 6·9 for fresh river water. It is thought that the accumulation of larval excreta in the tank was sufficient to account for the death of the colony.

Note added in proof. In a further rearing experiment in which the river water was changed completely every two days, the minimum length of the egg to adult cycle for males and females was 16 and 20 days respectively: the length of the larval stage varied from 14 to 40 days.

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Relation of Colchicine to Chromosome Breakage

Colchicine affects the mitotic spindle in a variety of ways[1–3]. It has also been claimed that colchicine will induce chromosome breaks[4,5]; but this effect has never been confirmed. Chromosome breaks have been found after treatment with old solutions of colchicine, but this action can be attributed to bacterial toxins, which are formed as the solution ages, and not to the colchicine itself[6].

To test for the ability of colchicine to induce chromosome breaks in *Vicia faba*, I have grown beans in aerated distilled water in a cabinet at 20° C. When lateral roots had formed, the beans were kept in a 0·05 per cent aqueous solution of colchicine for 3 hr. After 24–30 hr., 60 diploid nuclei and 60 of the induced tetraploid nuclei were examined at metaphase. No chromosome breaks were seen in either diploid or tetraploid cells. Colchicine as such does not appear, therefore, to have a direct effect in inducing chromosome breaks. This confirms the results of Gaulden and Carlson[3].

In addition to its independent or direct effects, colchicine has been thought to alter the sensitivity of cells to X-rays, that is, to exert an indirect effect. Thus combined treatments have been said to result in: (1) a reduced frequency of 'chromatid aberrations'[7]; (2) an increased frequency of 'reunions and restitutions' among broken ends[8]; (3) an enhanced inhibition of root-tip growth[9]; (4) an increased mutation-rate[10].

In order to obtain evidence of an indirect effect of colchicine on the production of chromosome breaks by X-rays, I kept beans in 0·05 per cent colchicine for 3 hr. and then irradiated them. Other beans

Table 1. Breakage and Reunion in Diploid Cells of *Vicia faba* Roots. X-ray Dose, 120 r. delivered in 1 min. B'' and B', Chromosome and Chromatid Breaks; R'' and R', Chromosome and Chromatid Reunions; C_0SR and C_1SR, Sister Reunion in Acentric and Centric Fragments

Colchicine pretreatment	Hr. after X-raying	Diploid cells		Total breakage and reunion						B and R per cell		
		Total	Broken	B''	B'	R''	R'	C_0SR	C_1SR	B''	B'	R'
Control	6	58 (5)*	50	35	132	—	45	4	—	0·60	2·27	0·78
Treated	6	62 (2)*	50	43	138	—	46	5	3	0·69	2·22	0·74
Control	24	72 (3)*	50	74	16	2	6	3	—	1·03	0·22	0·08
Treated	24	74 (2)*	50	77	21	4	5	5	2	1·04	0·28	0·06

* Unscorable

received no colchicine before irradiation (Table 1). Roots were fixed in 2BD and prepared as Feulgen squashes. The symbols used in scoring were those of Darlington and La Cour[11].

Breakages and reunions were scored in diploid nuclei. The mean frequencies of B'', B' and R' (6-hr. fixation) and B'' (24-hr. fixation) in roots with or without colchicine pretreatment are not significantly different ($P = 0{\cdot}05$–$0{\cdot}06$, about 0·56, about 0·5 and about 0·8 for the four types of aberration). Thus the evidence from this experiment is that pretreatment with colchicine has no effect on the frequency of chromosome breaks. At least this is true so far as concerns cells or chromosomes irradiated during the resting stage.

Now, if the chromosomes of diploid cells are held at metaphase by colchicine and then irradiated, any breaks which are induced can be scored in the tetraploid metaphases which occur 24 hr. later. The amount of breakage found in such tetraploid cells indicates that sensitivity to X-rays is higher at metaphase than at any other stage of mitosis[12]. (This observation I have confirmed.) This may come about, broadly speaking, in one of two ways. Either the colchicine increases the total production of chemical intermediates, which may form after irradiation, or it changes the state of the chromosomes thus changing their sensitivity.

In view of the lack of interaction during interphase the first possibility seems unlikely. We should have to postulate that the chemical intermediaries are increased, but only in the cytoplasm, and that they are unable to penetrate the nuclear membrane owing to a second effect of colchicine during the resting stage. The second possibility is that colchicine changes the state of the chromosomes. To test this, the obvious method would be to irradiate diploid cells arrested at metaphase by two kinds of treatment, by colchicine and by another agent, and to compare the breakage frequencies in the tetraploid metaphases which appear later. But this method cannot be used. Low temperatures, for example, lead to an increase in the number of chromosome breaks induced by X-rays[13]. Paradichlorobenzene produces arrested metaphases, but either fails to induce tetraploidy, or, like 8-oxyquinoline kills the root-tips. In these circumstances we can turn to cells which can be timed without being arrested, namely, to such synchronized cells as we have at meiosis.

In meiotic cells, in the absence of pretreatment, sensitivity to X-rays is higher at metaphase than at any other stage[14,15]. It seems reasonable to conclude therefore that in mitotic cells at metaphase, whether in root-tips or in animal tumours[16], pretreatment with colchicine is not responsible for the high sensitivity to X-rays: the effect is inherent in the stage. It remains to inquire whether what is inherent in the stage is the character of the cytoplasm or the chromosomes.

I am grateful to Mr. J. F. Scott for advice on statistical treatments and to the Nuffield Foundation for financial assistance.

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Experimental Evidence for an Allergic Basis for Granuloma Formation in Man

Granuloma formation is one of the significant reaction patterns of the body in disease. Characterized by tubercles of closely packed epithelioid cells, granulomas are the basic alteration in such chronic diseases as tuberculosis, leprosy, syphilis, sarcoidosis, deep fungus infections and in reactions to foreign material. These epithelioid cells are of reticulo-endothelial origin and may be regularly produced by the introduction of colloidal materials[1,2]. Other than this, little is known concerning their origin. The present communication describes the production of a specific, hypersensitive, delayed reaction to zirconium which manifested itself as a granuloma.

Recently, axillary granulomas have been described as arising in association with the use of zirconium-containing deodorants[3]. In the course of an extensive study[4] of the nature of this new clinical entity we performed the following experiments on normal healthy adult male volunteers. Each of ten subjects received four injections of 0·02 ml. of a 1·0 per cent aqueous solution of sodium zirconium lactate into the skin and four into the subcutaneous tissue of the upper arms. In all the men a small, firm fibrous papule developed at the sites of the intradermal injections whereas the subcutaneous injection sites could not be identified clinically. Biopsy of one of the papules in each man at one month revealed a

non-inflammatory fibrous mass, histologically resembling a scar. All the lesions remained unchanged clinically during the next six months and selected biopsies during this period showed simply fibrous tissue.

At the end of six months one of the subjects, No. 7, suddenly developed an enlarging mass at the site of each of the eight previous injections. The growth of these masses continued, and they eventually became nodules, approximately 5 cm. in width. Biopsy specimens disclosed a classical epithelioid granuloma in both the dermal and subcutaneous injection sites. The entire dermis was replaced by nests of epithelioid cells with minimal round cell infiltration. Quantitative spectrographic analysis of one of the nodules, in a site injected nine months previously, revealed zirconium persisting in a concentration of 10^{-5}. A control specimen from a nine-months old injection site (non-granulomatous) in another subject proved to have zirconium in a concentration of 3×10^{-5}, and in normal control skin zirconium could not be detected.

Careful study revealed that at six months No. 7 had acquired a state of allergic hypersensitivity to zirconium. Although the other members of the test group showed no clinical or histological response to intradermal injections of sodium zirconium lactate, No. 7 was now found to be sensitive out to a dilution of 10^{-6}. Repeated study of his response to 0·02 ml. of 10^{-5} revealed a clinical and histological response by seven days. At this time at the injection sites small papules appeared which on biopsy were found to be patchy, perivascular infiltrates consisting mainly of epithelioid cells. Gradually these papules enlarged due to the progressive development of a widespread epithelioid growth. These papules persist at the time of writing, four months after the injections. This response was reproducible in all areas of the skin. Furthermore, it was produced not only by sodium zirconium lactate but could also be elicited with dilute solutions of zirconium chloride and zirconium sulphate. However, no response was found after injecting silicon dioxide and beryllium sulphate in a concentration of 10^{-4}, thus indicating the specificity of the zirconium ion. It is to be noted that these two elements, silicon and beryllium, have been reported to cause granulomas[5,6].

Additional evidence for the concept that granulomas can have an allergic pathogenesis was provided by the study of six patients who had developed axillary granulomas following the clinical use of zirconium deodorants. In each of these patients it was possible to demonstrate delayed local granuloma formation at the injection sites of 0·02 ml. of 10^{-3} of sodium zirconium lactate. Twenty control subjects showed neither clinical nor histological response to this injection.

The allergic nature of these granulomas was apparent since:

(1) The state of hypersensitivity to zirconium was acquired. Subject No. 7 did not have an innate or inherited sensitization but developed it as a result of exposure to the injected zirconium. It is significant that in No. 7 the injected zirconium served both as a sensitizing and eliciting stimulus as proved by the spectrographic analysis of his tissue.

(2) The granuloma reaction was specifically elicited only by zirconium. The patients failed to react to dilute solutions of any of the other constituents of the deodorant preparations which they had used.

(3) Extremely high dilutions of the zirconium were capable of producing the granulomatous response. Classic allergic reactions are based on an antigen–antibody immunological reaction. No circulating antibodies could be demonstrated by us—but studies are now in progress concerning the passive transfer of cellular antibodies. It must be emphasized that the allergic state we have demonstrated was a generalized hypersensitivity not limited to one area of the skin. Moreover, it was not restricted to the dermis or true skin, but was also present in subcutaneous tissue.

Although an allergic basis for granulomas has been suspected[7,8], this, to our knowledge, is the first direct demonstration that the introduction of extremely small amounts of a substance may produce a delayed allergic reaction in the form of an epithelioid cell granuloma. There was no evidence that this was an Arthus or Schwartzman phenomenon. Furthermore, one must contrast this type of allergic response with the eczematous contact dermatitis seen as a result of an allergic reaction to metals such as nickel. None of the individuals studied showed any response to patch tests to zirconium. It is also to be noted that this allergic type of granuloma is to be distinguished from other non-allergic types which represent simple direct phagocytosis of exogenous or endogenous matter. Further study should reveal which of the granulomas seen in disease are allergic and which are non-allergic.

It has been possible, therefore, to demonstrate, both experimentally and clinically, that man may develop a delayed granulomatous epithelioid cell response as a result of a specific, acquired, generalized hypersensitivity to a simple metallic element.

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The Clock Paradox of Relativity

The clock paradox of relativity is, in my view, due to an error in Einstein's paper[1] which has not hitherto been noted and which may be more obvious to an experimental than to a theoretical physicist. Prof. H. Dingle has suggested[2] that there must be an error in this section of the paper without pointing out what I believe to be its true nature or giving the true explanation.

Einstein describes an imaginary experiment in which M makes a round trip from S and he concludes that the clock on M reads αT compared with the reading T of a clock on S. He does not give his reasoning, which must, however, have been connected

with observations made on the two clocks. It is important, therefore, to distinguish between the two parts of a clock, the time standard which supplies regular impulses and the dial which counts them.

The time dilatation is an effect obtained when the rate of the clock on M is determined by observations made on S. These measurements cannot be made by reading the figures on M's dial as this is simply reading the result of a measurement made on M. They must be made by receiving the impulses from M's standard and counting them on a dial on S, and it is this dial which reads αT when the dial of S's local clock reads T. The measurements do not give any indication of the reading on M's dial; but this can be observed directly at the end of the journey, and it follows from the postulate of relativity, if acceleration effects are ignored as in Einstein's paper, that the reading will be the same as that of the local clock on S. If there is also a dial on M recording the impulses from S this will read αT. The observations on M and S are completely symmetrical and there is no paradox.

To anticipate possible criticism, two further points might be made. (1) The result is not in accordance with pre-relativity ideas of the nature of electromagnetic waves; but this is only to be expected, since these ideas are abandoned with the acceptance of the relativity postulate of constant velocity. (2) Many writers, including Einstein[3], accept the paradox result but attribute it to the accelerations which must be involved. This argument is, I think, illogical. An imaginary experiment can yield only a result which is already present in some form in the data given. Since no data concerning the effects of acceleration are included, the result cannot be a consequence of acceleration. The result may, however, be wrong because such data have been omitted.

If the views presented here are correct, the consequences are far-reaching. Many text-books need to be revised, and as the paradox seems to be confirmed by the general theory of relativity some aspects of this theory may need to be critically examined.

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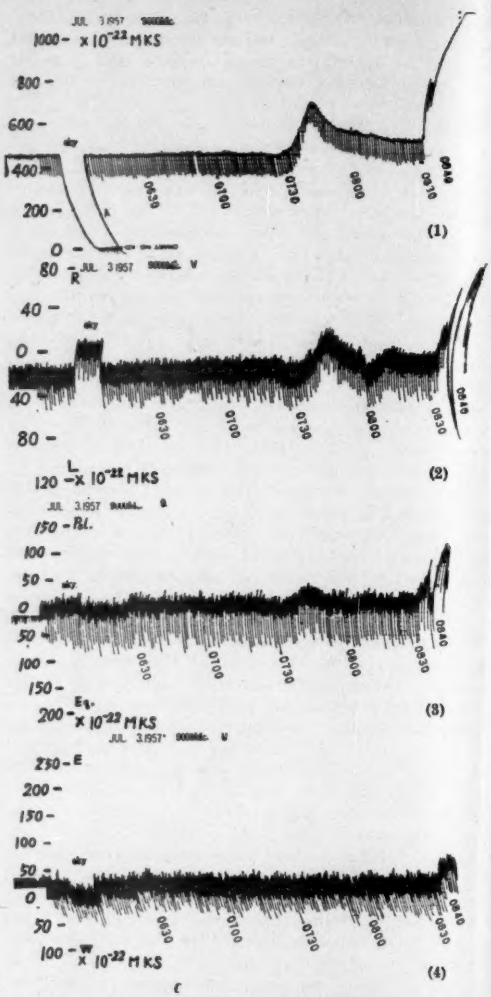
Polarization of Solar Radio Outbursts

It has been reported through the International Geophysical Year networks that three large solar flares were observed on July 3. Our radio observations at 9,000 Mc./s. showed some interesting phenomena in the polarization of radio outbursts which correspond to these optical flares. As is described elsewhere[1], our receiver working at this frequency is so designed as to record four of the Stokes's parameters of polarization directly by the method of phase-modulation. Figs. 1–4 show the tapes which record I, V, Q and U, respectively.



Figs. 1–4. Reproductions of tapes of solar radio emission on July 3. They represent the four components of Stokes parameter on polarization, namely, I, V, Q and U, respectively. R and L, in Fig. 2, refer to the right-handed circular and left-handed circular components, respectively. *Pol.* and *Eq.*, in Fig. 3, refer to the linearly polarized components in the direction of celestial equator and pole, respectively. E and W, in Fig. 4, denote the linearly polarized components in the direction inclined 45° to the east and west, respectively, from the direction of the celestial pole

At 0727 U.T. the flux started to rise and, passing the 20 per cent point at 0733 U.T. (the starting time by the usual definition), it reached a maximum of 710×10^{-22} M.K.S. units (including the background flux) or 230×10^{-22} M.K.S. units (excluding the background flux) at about 0742 U.T. The sense of the circular polarization of the general background on the day was left-handed, as is seen by reference to the position marked 'sky' on Fig. 2, but at the time of this outburst the polarization changed to 10 per cent right-handed. The starting time of the optical flare of importance 2 +, as reported by the Simeis Observatory, is 0726 U.T.

At 0800 U.T. there is a small kick in Fig. 1, and Fig. 2 shows a change of circular polarization at this

time. This seems to correspond to the second optical flare of importance 3 reported by the Arcetri Astrophysical Observatory, starting at approximately 0802 U.T.

There is a sudden increase in flux at 0831 U.T. which sent the recording arm of the receiver off-scale a few minutes later. This corresponds to the third optical flare, starting at 0832 U.T., reported by the Arcetri observers. An interesting thing is that the state of polarization of the radio outburst changed considerably, as is seen from Figs. 2 and 3. Since this radio-telescope is driven quite automatically from morning until evening and then driven back to the morning position through the night, no record after 0844 U.T. was obtained.

The change of polarization of radio outbursts might be connected with the shift of the activity centre of the flare relative to the sunspot magnetic field. It is highly desirable that these observations should be compared with optical observations of the flares.

There is one more point which we would like to make: at about 0723 U.T. the flux decreased slightly. The polarization tapes, Figs. 2 and 3, also show simultaneous changes in polarization. A similar phenomenon was also observed on a smaller scale on July 1, just before the occurrence of a similar 'slow rise and fall' type of outburst which started at 0347 U.T.

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Nuclear Magnetic Resonance of Methane adsorbed on Titanium Dioxide

NUCLEAR magnetic resonance can be used for studying the motions of molecules absorbed on surfaces. In this connexion proton-resonance derivative line-shapes have been obtained for methane adsorbed on titanium dioxide at various coverages from 0·1 to

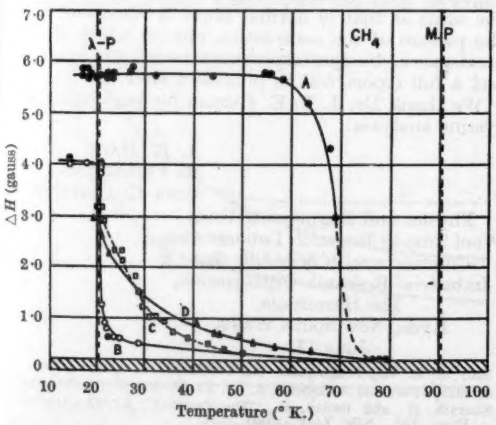

Fig. 1. Derivative line-width ΔH versus temperature for (*A*) bulk methane; (*B*) 0·9 monolayer; ○, temperature increasing; ●, temperature decreasing; (*C*) 0·5 monolayer; (*D*) 0·33 monolayer

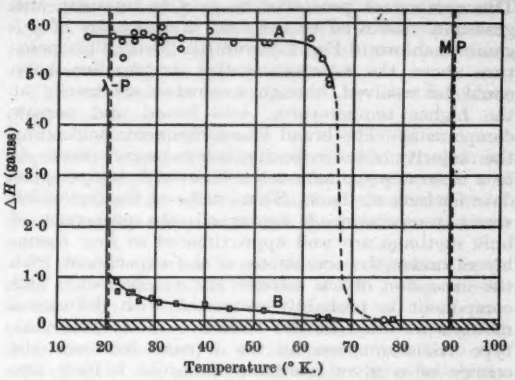

Fig. 2. Derivative line-width ΔH versus temperature at 3·9 monolayer of methane on titanium dioxide: (*A*) broad line component; (*B*) narrow line component

4·0 monolayer, and also in bulk methane, as a function of temperature. The surface area of the titanium dioxide, determined by the BET method, was 230 m.²/gm.

The results for bulk methane are shown in Fig. 1, and, as in the previous work[1,2], no change in derivative line-width ΔH is observed on passing through the λ-point at 20·4° K. A theoretical analysis by Tomita[3] has indicated that the 'flipping' of methane molecules to neighbouring equivalent orientations provides a good explanation of the small value of T_2 ($\sim 10^{-4}$ sec.) actually observed. Moreover, this re-orientation occurs with sufficient frequency to average out the intra-molecular contribution to the line-width even at temperatures well below the λ-point. Thus the absence of a line-width transition at this temperature cannot in itself exclude the possibility of hindered or free rotation[3,4] being associated with the λ-transition. The most effective mechanism for narrowing the line-width due to inter-molecular local fields is diffusion[2]. Thus the incidence of line-width narrowing, initiated near 60° K., to a value below the field homogeneiety of 0·3 gauss at 75° K. is probably to be ascribed to this cause. The low magnitude of the correlation frequency for line narrowing ($\sim 2{\cdot}5 \times 10^4$ c./s.) and the spherical symmetry of the methane molecules indicate that this process may be interpreted as anticipating the more rapid diffusional processes known to accompany melting at 90° K.

At a coverage of 1·0 monolayer an unexpected line-width transition is observed at 20° K. The line-shape is, however, complex, and only a certain fraction of the molecules undergo the sharp line-width transition indicated in Fig. 1. As the coverage is reduced below a monolayer the transition becomes progressively more gradual with respect to increasing temperature.

Below the λ-transition the derivative line-width for both bulk methane and 3·9 monolayer coverage is 5·7. For one monolayer it is 4·1 gauss, which is lower than the value at higher coverages, as may be expected since a single monolayer will have fewer near neighbours. As the temperature is increased from 15° K. through the λ-transition the line-width remains at 5·7 gauss for the 3·9 monolayer coverage as it does for the bulk methane. However, at this coverage a central narrow line component of initial width 0·9 gauss had appeared at $20{\cdot}8 \pm 0{\cdot}3°$ K.

This component proceeded to grow in intensity and gradually narrowed to the field homogeneity of 0·3 gauss as shown in Fig. 2 (curve *B*). At each temperature above the λ-transition the complex-line-shape could be resolved, though somewhat arbitrarily at the higher temperatures, into broad and narrow components. The broad line component, containing the majority of the intensity, is seen to give (curve *A*) to a close approximation the line-width temperature data for bulk methane. Thus, so far as the line-width versus temperature is concerned, the properties of bulk methane are well approximated at four monolayers under the conditions of the experiment with the exception of the narrow line component. This component is probably associated with diffusional motions initiated at the surface. As a rotational-type transformation at the λ-point increases the energy of a given methane molecule, it may also increase the probability for surface diffusion. This would explain the first appearance of the narrow line component at 20·9° K. A more detailed analysis of these effects is proceeding.

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Supercontraction of Wool irradiated with Ultra-violet Light or Iodinated

Supercontraction of Corriedale wool fibres in solutions of lithium bromide (6 *M*–10 *M*), freed from bromine, has been shown to proceed in two stages, the first stage being complete at contractions of about 15 per cent and the second stage at about 40 per cent. It can be reversed up to the end of the first stage by washing out the lithium bromide with water. If supercontraction is allowed to proceed into the second stage, washing can at best only partially restore fibre-length[1,2]. The second stage has an activation energy deduced from the temperature coefficient of the process of about 30 kcal./mol. in the lithium bromide solution. Haly and Feughelman[1] concluded that the fibre, at the end of both the first and second stages, acted as an elastomer which had respectively 16 and 30 residues between 'vulcanized' sites. It was suggested that at the end of the first stage the 'vulcanizing' linkages are strong polar bonds or co-operative secondary bonds (such as exist in crystalline regions) and disulphide bonds, and that at the end of the second stage only the disulphides remain.

Wool fibres, after ultra-violet irradiation from a high-pressure mercury-in-quartz source, when heated in lithium bromide solution, supercontract much more rapidly than normal fibres, and there is no indication of two-stage behaviour. These phenomena remain when wave-lengths shorter than 2900 A. are eliminated, but a longer time of irradiation is required. In both cases the activation energy was substantially reduced.

The disulphides in wool absorb ultra-violet radiation[4]. Although it was found that the amount of cystine lost after irradiation for 2 hr. by wave-lengths above 2900 A. was approximately 25 per cent of the total, there was no further loss of cystine during 200 hr. exposure. On the other hand, increasing the time of irradiation from 2 to 20 hr. greatly increased the rate of supercontraction in lithium bromide solution. It therefore seems unlikely that this cystine fraction plays any part in the supercontraction process. Furthermore, no change in the load-extension curves of single fibres in water could be detected due to this loss of 25 per cent of cystine. Tyrosine and tryptophan at neutral *p*H absorb in the ultra-violet mainly between 2500 A. and 2900 A. in the free state. The maximum is at about 2750 A. Incorporation into peptides results in the loss of fine structure together with a shift of absorption to longer wave-lengths[3]. (The absorption spectrum of horn keratin was determined by Speakman and McMahon[4].) Phenylalanine, the only other aromatic amino-acid present in wool, absorbs mainly around 2600 A.

Further evidence was sought relating to the linkages which break to permit the second contraction stage. Corriedale fibres in which the tyrosine residues had been iodinated by the Richards and Speakman technique[5] were contracted in lithium bromide solution. Contraction behaviour was normal up to the end of the first stage, but the subsequent rate of contraction was extremely slow. In this respect the response of iodinated fibres was similar to that of normal wool supercontracted in solutions of lithium bromide containing bromine[2]. Wool fibres which had been exposed to ultra-violet radiation, however, supercontracted rapidly into the final stage in solutions of lithium bromide in which a normally effective concentration of bromine is present. As a further check, in case a reaction between lithium bromide and iodinated wool might be producing side-effects, some iodinated wool was supercontracted in calcium nitrate solution, with results similar to those obtained using solutions of lithium bromide.

This evidence suggests that tyrosine may be involved in the strong polar bonds or co-operative secondary bonds which, when broken in lithium bromide solution, allow the second supercontraction stage. The evidence of Richards and Speakman[5] that supercontraction of iodinated fibres in a disulphide bond-breaking reagent was approximately the same as that of normal fibres is consistent with the picture of the contraction process which is outlined above. Further experimental work is in progress, and a full report will be published later.

We thank Dr. J. P. E. Human for performing the cystine analyses.

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Degradation of Cellulosic Fibres in Contact with Rusting Iron

INSTANCES of rapid degradation of textile materials in industrial use have been noted, the cause of which could not be attributed to the more usual degrading agencies, that is, micro-organisms, heat, light or acids. It was significant that in each of these occurrences there was evidence that the cellulosic material had been in contact with corroding iron under damp conditions. Similar degradation was observed in laboratory experiments in which cellulosic fibres were placed in contact with a clean iron surface and kept moist, a rapid fall in tensile strength being found as corrosion proceeded. The curves in Fig. 1 show the loss in strength of cotton yarn (8's × 5) damped with distilled water (curve *A*) and with 0·02 per cent sodium chloride solution (curve *B*) when wound on polished mild steel rods and kept in a moist atmosphere. Yarn wound on glass rods and exposed under the same conditions showed no significant change of strength in the same period (curve *C*).

An explanation of the cause of this degradation follows from consideration of the generally accepted electrochemical mechanism for the corrosion of iron wetted with a neutral salt solution. According to this mechanism, a flow of current occurs between separate regions of differing potential on the iron surface, the electrode reactions being expressible as:

Anodic reaction: $Fe \rightarrow Fe^{2+} + 2e$

Cathodic reaction: $O + H_2O + 2e \rightarrow 2OH^-$

If sodium chloride is present in the solution, the cathodic and anodic products can be regarded as sodium hydroxide and ferrous chloride respectively.

When cellulosic fibres are saturated with sodium hydroxide solution and exposed to the air, oxygen is consumed and the cellulose molecules are broken down. This reaction, which is the basis of the pulp 'ageing' process in viscose manufacture, has been studied fairly extensively[1,2], and it has been shown, and confirmed in this laboratory, that two of the main factors affecting the rate of cellulose degradation are: (*a*) the concentration of sodium hydroxide in the fibres; (*b*) the concentration of certain metals in the fibres, for example, iron, cobalt, nickel, etc., which are catalysts for the reaction. Moist cellulosic fibres in contact with rusting iron will thus be in an environment highly conducive to oxidative degradation by virtue of (*a*) the presence of local concentrations of alkali and (*b*) the presence of iron ions, which are active catalysts for the oxidation.

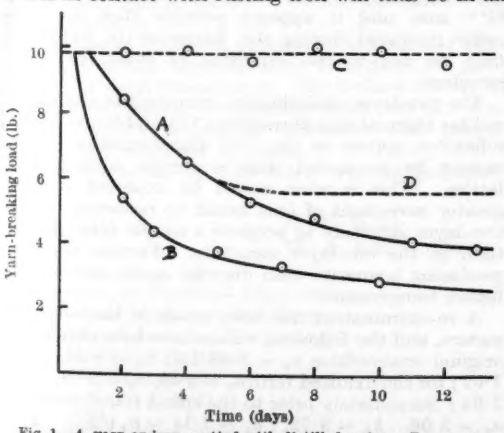

Fig. 1. *A*, yarn on iron, wetted with distilled water; *B*, yarn on iron, wetted with 0·02 per cent sodium chloride solution; *C*, yarn on glass, wetted with distilled water; *D*, yarn removed from iron

This explanation is supported by the following observations.

(1) Yarn wound closely on a rusting iron rod acquired a mottled pattern of rust-stained and unstained zones, the stained parts having a neutral and the unstained an alkaline reaction. Degradation of the fibres was most severe at the junctions of these zones.

(2) Yarn wetted with salt solution degraded faster than that wetted with distilled water. This is consistent with a difference in the level of alkali concentration reached in the cathodic zones resulting from the difference in conductance (and thus the rate of OH^- ion production) and in the availability of sodium ions to balance the hydroxyl ions. The results with distilled water suggest that enough alkali metal ions were present as impurities in the yarn (which was not specially purified) to produce sufficiently high local concentrations of hydroxide to promote the degradation observed.

(3) Yarn removed from rusting iron after losing 40 per cent strength, and thereafter kept moist, suffered no significant further loss in strength (curve *D*). Removal of the fibres from the alkali-generating sources on the iron surface would be followed by a fall in the local alkali concentrations by diffusion and reaction with iron ions to form rust, and the rate of cellulose oxidation would diminish rapidly.

(4) The strength of cotton yarn, saturated with a thick aqueous slurry of finely divided sulphur, was found to be unimpaired after 28 days in contact with an iron rod in a moist atmosphere. Under these conditions, in confirmation of Farrer and Wormwell's observations[3], very rapid and severe corrosion of the iron occurred and the yarn became heavily impregnated with a black corrosion product. In this system it may be assumed that the sulphur takes the place of oxygen in the normal cathodic reaction, sulphide ions being formed instead of hydroxyl ions, thus:

$$S + 2e \rightarrow S^{2-}$$

Since no alkalinity is produced, no oxidative breakdown of the cellulose would occur.

(5) Two samples of cotton yarn, the first impregnated with 5 per cent magnesium sulphate + 0·1 per cent sodium chloride, and the second with 0·1 per cent sodium chloride only, were damped and exposed on iron rods. The iron corroded rapidly in both cases, the rate being slightly less in the presence of magnesium sulphate, but while the yarn containing only sodium chloride degraded rapidly, the yarn treated with magnesium sulphate showed no loss in strength after 23 days. The precipitation of hydroxyl ions as magnesium hydroxide evidently prevented the development of sufficient alkalinity to promote oxidation.

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Crystallography and Thermal Transformations of Cronstedtite

The iron hydrous layer silicate cronstedtite is unique in having ferric iron substituted for silicon in positions of tetrahedral co-ordination. Previous investigations have been made by Gossner, and Hendricks[1], who described its crystallography as a kaolin-type structure with an orthorhombic three-layer unit cell.

Other iron-bearing layer silicates of the kaolin-antigorite and the chlorite groups have shown interesting reactions during the course of thermal decomposition. Certain of these phenomena have been observed by Holzner[2] in some chlorite minerals. In general, ferrous iron in these structures undergoes oxidation at about 300–400° C. without breakdown of the lattice. The charge balance is maintained by the alteration of a hydroxyl to an oxygen ion for each ferrous ion oxidized. This is accompanied on the X-ray diagram by a reduction of all d-values and a general deterioration of clarity with broadening of certain lines indicating the incidence of some disorder. At higher temperatures the hydroxyl ions remaining in the structure may be eliminated as water with partial or complete breakdown of the lattice to an amorphous state or to another crystalline species. This occurs with iron-bearing kaolin structures at about 500° C., and with chlorite minerals in two stages at about 550 and 700° C., representing degradation of the brucite- and talc-type layers respectively. The oxidation and dehydration mechanisms sometimes interfere in specimens with a high iron content because the loss of hydroxyl ions on oxidation renders the dehydration reaction much less clear.

In view of the importance of these reactions from the structural mineralogy point of view, cronstedtite was examined to compare its thermal decomposition behaviour with that of other iron silicates. Specimens examined from Cornwall and Rumania contained single crystals showing considerable polymorphism. Hendricks's three-layer structure was identified but appeared to be comparatively rare. One-layer orthorhombic, two-layer orthorhombic and six-layer orthorhombic types, and a somewhat disordered specimen which was substantially monoclinic, were identified. The one-layer structure had a straightforward kaolin-type orthorhombic unit cell, and the two-layer structure was very similar to that of the amesite described by Brindley, Oughton and Youell[3].

Powder photographs taken of specimens not good enough for single-crystal analysis showed a wide diversity of diffraction diagrams, in which orthorhombic and monoclinic reflexions were present, similar to the case of the chamosite described by Brindley[4,5].

The thermal decomposition of cronstedtite showed a number of novel and unexpected features. The oxidation of the ferrous iron took place at 275° C., substantially lower than for other ferrous silicates but with the usual contraction of the lattice which may be attributed to the small size of the ferric ion compared with the ferrous. On heating above this transition temperature there was a progressive change in the lattice parameters; a_0 and b_0 continued to decrease appreciably and c_0 increased to a value greater than that of the original cronstedtite. At about 700° C., this alteration in the unit cell dimensions had progressed to a stage where $c_0 = a_0\sqrt{2}$, giving orthorhombic parameters in the ratio $1 : \sqrt{3} : \sqrt{2}$.

At this temperature and, to some extent, at lower temperatures, a reaction occurred, producing a cubic spinel-type substance closely resembling γ-ferric oxide. An orthorhombic cell with the above dimensions is simply related spatially to a cubic cell with its diagonal (111) in the orthorhombic c-direction, which is a three-fold rotation axis for both structures. The (211) direction of the cubic unit cell is parallel to the a-axis of cronstedtite and the (110) direction of the cubic unit cell is parallel to the b-axis of cronstedtite. Certain of the stronger X-ray reflexions are identical in the two structures, notably the (060) of cronstedtite, which becomes the (440) of the spinel. The sites of the O and OH ions in cronstedtite are nearly coincident with the O sites in the spinel structure, but some rearrangement of the positive ions is necessary. There is no evidence either, by way of disorder occurring or of free silica appearing, that silicon ions have been removed from the lattice as a result of this transformation. It appears possible that the silicon ions may remain in the spinel structure, which has sites in tetrahedral co-ordination suitable for them. It is noteworthy that this spinel structure, although closely resembling γ-ferric oxide, has a higher decomposition temperature than the simple oxide, and this would appear to support the concept of silicon ions remaining in the lattice. The replacement of ferric iron in a spinel structure by silicon ions is unexpected, but the occurrence of the reverse substitution in cronstedtite has been generally accepted.

At above 750° C. a transformation to hæmatite occurs, with considerable disorder and powder streaking appearing on the single crystal X-ray photograph. Well-developed cristobalite is identifiable at higher temperatures. Sufficient single crystal reflexions can be identified to suggest that one of the possible directions of the c-axis of the hexagonal hæmatite unit cell is parallel to the c-axis of the original cronstedtite, the $13{\cdot}73\,kX$ c_0-dimension of the hæmatite unit cell corresponding to $14{\cdot}14\,kX$ for two cronstedtite layers.

The hæmatite structure, unlike the spinel type, has no tetrahedral cation sites suitable for Si^{4+} ions, and it appears possible that the disorder produced during the formation of hæmatite may be due to the expulsion of silica from the structure.

The two-layer orthorhombic cronstedtite undergoes similar thermal transformations but additional X-ray reflexions appear at the 700° transformation which cannot be reconciled with a simple cubic spinel lattice. This is what would be expected since a greater movement of ions would be necessary in the two-layer structure to produce a simple cubic lattice than in the one-layer structure. Further reaction producing hæmatite with disorder again occurs at a higher temperature.

A re-examination has been made of lattice parameters, and the following values have been obtained: original cronstedtite $a_0 = 5{\cdot}48\ kX$, $b_0 = 9{\cdot}50$, $c_0 = 7{\cdot}07$; for the oxidized form $a_0 = 5{\cdot}24$, $b_0 = 9{\cdot}08$, $c_0 = 7{\cdot}04$; immediately prior to the spinel transformation $a_0 = 5{\cdot}06$, $b_0 = 8{\cdot}72$, $c_0 = 7{\cdot}14 = a_0\sqrt{2}$. The d-values of the original cronstedtite are in substantial disagreement with those quoted by Bannister[6] but are very close to those of Frondel (private communi-

cation), who has been investigating cronstedtite independently of the present work.

We are indebted for the supply of specimens to Drs. Sabine and Dunning of the Geological Survey in London, Drs. Claringbull and Embrey of the British Museum (Natural History), London, and Dr. Hendricks, who kindly made available some of his original material. A full account of this work will be published later.

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A Phase Change induced by Cold Work

A phase change has been produced in the ζ-phase of the alloy AgZn by cold work. The ζ-phase transforms to the β-phase on filing. The lattice parameter of the β-phase agrees with that found by Owen and Edmunds[1].

The structure of the ζ-phase has been determined by Edmunds and Qurashi[1] and confirmed by Bergman and Jaross[2]. The body-centred cubic β-phase and the ζ-phase hexagonal structure are closely related, the latter being obtained from the β-phase by displacement of the atoms mainly in the direction of one of the cube diagonals. Edmunds and Qurashi[2] have shown that both structures may be considered to have a unit cell containing nine atoms, and that in the ζ-phase the zinc atom at the origin has an abnormally high temperature vibration parallel to the hexagonal axis.

The rate of change is dependent on time and temperature, taking approximately four days for completion at room temperature. The β-phase reverts to ζ-phase on heating to approximately 130° C. Our present results suggest a nucleation and growth mechanism activated by stress.

A full account of this work will be published later.

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Relationship of the Strength of High Solids Pectin Gels to the Concentration and Jelly-forming Capacity of the Pectin Present

In 1940 Hinton[1] put forward a theory which was capable of explaining quantitatively many of the phenomena associated with the formation of high solids pectin gels. More recently, the assumptions on which Hinton based his theory have been criticized and an alternative explanation suggested which is more in keeping with current theories of the properties of macromolecules[2]. Neglecting the small variation in the degree of dissociation of pectin with concentration[1,2], for a given pectin in a gel of specified soluble solids content and *p*H, both theories indicate a linear relationship between gel strength and pectin concentration. However, a review of a number of the published curves relating the gel strength and the pectin concentration shows that when the strength is measured within the elastic limits of the gel and is expressed in units proportional to an elastic modulus, in each case the curve obtained is convex to the pectin concentration axis[4–11] (gel strengths measured by means of the ridgelimeter[9–11] may be converted from percentage sag to shear moduli by means of the curve given by Owens and Maclay[12]). Similar curves have been obtained by some workers measuring the breaking strengths of the gels[13–15], although in some instances a linear relationship was found[16,17].

Linear relationships between log (gel strength) and log (pectin concentration) have been demonstrated previously[4,5,13,14]. Some of the published curves from

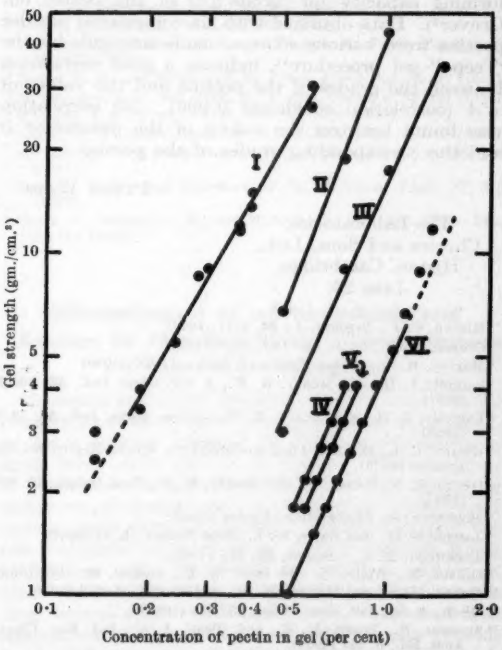

Fig. 1. Gel strength versus pectin concentration curves from various sources. Curve I from Hinton (ref. 6), II and III from Säverborn (ref. 8), IV from Joseph and Baier (ref. 9), V from Olliver *et al.* (ref. 11), VI from Lockwood (ref. 10). In curves IV, V and VI the pectin concentration has been expressed in terms of '100 grade' pectin as defined in the respective methods

other sources for which sufficient data are available have been replotted in this manner in Fig. 1. In each of these examples the gel strength was measured within the elastic limits of the gels. Strengths measured with the ridgelimeter have been converted from percentage sags to shear moduli as described above. In each case the results approximate closely to a straight line.

The curves shown in Fig. 1, and those mentioned previously[4,5,13,14], can be fitted by a general equation of the form:

$$R = AP^n - B \qquad (1)$$

where R is the gel strength, P the pectin concentration and A and B are parameters, provided that B is small compared with AP^n. The inclusion of the parameter B is necessary in order that a positive value of P be obtained when $R = 0$. Zero gel strength is taken as the strength at the limiting pectin concentration where a gel just forms or just fails to form[1].

From their results, Lampitt and Money[4,5] showed that the gel strength was proportional to the square of the pectin concentration. The slopes of the lines in Fig. 1 also indicate that the value of n in equation (1) is approximately 2. The apparent linear relationship between gel strength and pectin concentration, giving $n = 1$, observed by some workers[1,16,17], may be due to the limited range of pectin concentration studied.

The values of the parameters A and B will depend upon a number of factors, including the pH and soluble solids content of the gel, and on the jelly-forming capacity (or 'grade'[9,13]) of the pectin (cf. Grover[2]). Data obtained with six commercial powder pectins from various sources, made into gels by the 'Teepol'–gel procedure[11], indicate a good correlation between the grades of the pectins and the values of $\sqrt{A}$ (correlation coefficient 0·906). No correlation was found between the values of the parameter B and the corresponding grades of the pectins.

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Photochlorination of Chloroform

We have shown recently that the chain-breaking steps in the gas phase photochlorination of C_2Cl_4 and of C_2HCl_3[1] are:

$$\begin{aligned} C_2Cl_5 + Cl &\rightarrow \text{inactive products} \quad (7) \\ 2C_2Cl_5 &\rightarrow \text{inactive products} \quad (8) \end{aligned} \qquad \text{(i)}$$

(The numbers of the reactions have been chosen so as to have a uniform representation of all reactions: vide infra (ii); the products of these reaction steps are not known with certainty.)

Reaction (8) is predominant in the case of C_2Cl_4 up to 430° K. and (7) between 520° and 560° K. In the substitution reaction below 400° K., (7) and (8) are of equal importance; above 430° K., dehydrochlorination (ref. 1, IV) occurs, with (7) as the chain-breaking step.

We have now studied the photochlorination of chloroform, and have applied to this case the general mechanism (ref. 1, II) proposed some time ago and which permitted us to explain all the results for the system C_2Cl_4, C_2HCl_3, Cl_2 thus:

$$\begin{aligned} & Cl_2 \xrightarrow{h\nu} 2Cl && (1) \\ Cl + CHCl_3 &\rightleftharpoons CCl_3 + HCl && (2)\ (4) \\ CCl_3 + Cl_2 &\rightleftharpoons CCl_4 + Cl && (3)\ (5) \\ 2Cl + M &\rightarrow Cl_2 + M && (6) \\ Cl + CCl_3 &\rightarrow CCl_4 && (7) \\ 2CCl_3 &\rightarrow C_2Cl_6 && (8) \end{aligned} \qquad \text{(ii)}$$

All results have been treated by van't Hoff's method, plotting $\log v_i$ vs. $\log p(Cl_2)_t$, where v_t is the rate and $p(Cl_2)_t$ the pressure of chlorine at the time t. This yields n, the reaction order in the course of the reaction, and v_0, the initial rate of the reaction. A plot of $\log v_0$ vs. $\log p(Cl_2)_0$ for different initial chlorine pressures ($p(Cl_2)_0$) gives the reaction order $n_0 = 3/2$ in the initial conditions[2] (Fig. 1); n increases slightly with $p(Cl_2)/p(CHCl_3)$, having the value 3/2 for $p(Cl_2)/p(CHCl_3) = 1$. This result would be expected from the reaction sequence (ii), if, as in the case of C_2HCl_3, reactions (4), (5) and (6) are neglected and the steady-state treatment is applied:

$$v = I_a^{1/2}\, k_3(Cl_2)/[k_3k_7(Cl_2)/k_8(CHCl_3) + k_8]^{1/2} \qquad \text{(iii)}$$

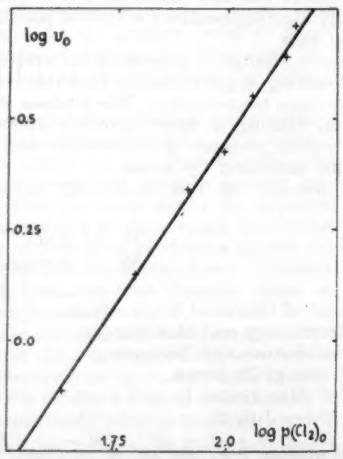

Fig. 1. Reaction order $n_0 = 3/2$ from a plot of $\log v_0$ vs. $\log p(Cl_2)_0$ for a ratio $p(Cl_2)_0/p(CHCl_3)_0 = 2$. v_0 in (mm. mercury) sec.$^{-1}$; p_0 in (mm. mercury). Measurements at 343° K.

Table 1

Reaction	$\log k_3/k_2^{1/2}$	$\log (k_1k_3/k_7)^{1/2}$	$\log k_5(k_1/k_4k_7)^{1/2}$
$Cl_2+C_2Cl_4$ (ref. 1, III)	$-660/T+2{\cdot}56$	—	$+1{,}725/T-1{\cdot}20$
$Cl_2+C_2Cl_4+C_2HCl_3$ (ref. 1, VI)		—	—
$Cl_2+C_2HCl_3$ (ref. 1, VI)		$-675/T+3{\cdot}05$	—
$Cl_2+C_2HCl_3$ (ref. 3)	$-1{,}060/T+3{\cdot}71$	—	—
Cl_2+CHCl_3	$-1{,}156/T+3{\cdot}96$	$-1{,}735/T+6{\cdot}03$	—
Cl_2+CO (ref. 4)	—		$132/T+1{\cdot}1$

According to (iii), a plot of $(Cl_2)^3/v^2$ vs. $(Cl_2)/(CHCl_3)$ yields a straight line, as shown in Fig. 2; the slope gives k_7/k_2k_3 and the intercept with the ordinate axis k_8/k_3^2. The plot of log k vs. $1/T$ (between 343° and 428° K.) gives the activation energy and the frequency factor. The results are collected in Table 1 and compared with the corresponding rate-constants for other substances.

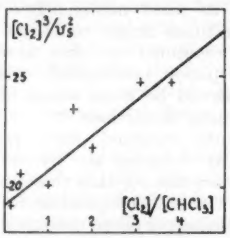

Fig. 2. Rate-constants k_7/k_2k_3 and k_8/k_3^2 from a plot of $(Cl_2)^3/v^2$ vs. $(Cl_2)/(CHCl_3)$. Concentrations in mole. l^{-1}; v in mole. l^{-1}) sec.$^{-1}$. Measurements at 380° K.

We conclude that:

(*a*) The van't Hoff method is a much more reliable and sensitive test for the mechanism of complex reactions than the integration methods used previously[5–7].

(*b*) The proposed scheme gives a better general picture of photochlorination reactions than the mechanism proposed by Schumacher[5,8] with chain-breaking step (8) for the reaction of C_2HCl_3 and

$$2CCl_3 + Cl_2 \rightarrow 2CCl_4$$

in the case of $CHCl_3$, this latter step being further in contradiction with Rollefson and Newton's observation[9] of C_2Cl_6 formation in the photochlorination of $CHCl_3$.

(*c*) We have also studied the competition reactions in a mixture of chlorine, chloroform and tetrachlorethylene. In this case the rate-equation is given by:

$$v = I_a^{1/2}(Cl_2)(k'_3 + k_3\beta/\alpha)\,(k'_7\beta + k'_8 + k_8\beta^2/\alpha^2 + k_9\beta/\alpha)^{-1/2} \quad \text{(iv)}$$

where the prime indicates the steps of the substitution reaction:

$$\alpha = (Cl)/(C_2Cl_3) = (k_3(Cl_2) + k_4)/k_5(C_2Cl_4) \text{ and}$$
$$\beta = (Cl)/(CCl_3) = k'_3(Cl_2)/k'_7(CHCl_3)$$

(9) is a new chain-breaking step:

$$CCl_3 + C_2Cl_5 \rightarrow \text{inactive products} \quad (9)$$

Table 2

Reaction	$\log k'_3/k_3$	$\log k'_3/k_7$
$C_2Cl_4+Cl_2$	—	$-510/T-2{\cdot}0$
$C_2Cl_3H+Cl_2$		
$C_2Cl_3H+C_2Cl_4+Cl_2$	$-1{,}300/T+2{\cdot}45$	
$C_2HCl_3+Cl_2$ (ref. 3)	—	$-1{,}006/T-1{\cdot}07$
$CHCl_3+C_2Cl_4+Cl_2$	$-1{,}540/T+3{\cdot}20$	$-1{,}688/T+0{\cdot}18$

which is, in fact, predominant. Thus this competition permits one to measure k'_3/k_3 and k'_3/k_9; the results are shown in Table 2 [10].

Complementary information on rate-constants of elementary reactions of chlorine atoms and chlorinated hydrocarbon radicals can now be obtained by continuing this study, based on a general scheme of type (ii) of photochlorination reactions, including measurements in intermittent light, and of competition reactions (ref. 1, VI).

We thank Prof. P. Goldfinger for valuable discussions, the Institut pour la Recherche Scientifique dans l'Industrie et l'Agriculture and the Centre National de Chimie Physique Moléculaire (Brussels) for financial assistance.

In the previous communication[1] in Table 1, rate-equation A should read $(I_a^{1/2}\,k_3/k_2^{1/2})\,(Cl_2)$ instead of $(Cl_2)^{3/2}$. All rate-constants are in (litre mole^{-1})$^{n-1}$ sec.$^{-1}$.

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Differentiation of α-Amino-Acids and Amines by Non-Enzymatic Transamination on Paper Chromatograms

Crumpler and Dent[1] devised a method based on the immobility of the copper complexes of the amino-acids in some solvent systems to differentiate α-amino-acids from other amines on paper. The behaviour of β-amino-acids is ambiguous, since they also form stable copper complexes, but occasionally yield visible mobile spots with ninhydrin[1]. α-Amino-acids[2,3] but not β-alanine[4] or most other amines undergo transamination with pyridoxal in aqueous solutions. Since the pyridoxamine formed gives a characteristic deep orange colour with ninhydrin it appeared that adaptation of the reaction to paper might provide a convenient means of differentiating α-amino-acids from β-amino-acids and other amines.

The mixture to be analysed is applied to duplicate papers, and the chromatograms are developed with the desired solvent. We have usually used the upper

layer of *n*-butanol–acetic acid–water (4 : 1 : 5) as the developing solvent, although the reaction appears largely independent of the solvents used. After drying in air to remove the solvent, one chromatogram is sprayed with a solution prepared by dissolving 0·25 gm. pyridoxal hydrochloride in 100 ml. of 95 per cent ethanol and adding sufficient alkali so that an aliquot diluted in water has a *p*H of 5·5, then again drying in air at room temperature. Compounds that contain the primary amino group appear yellow at this stage, presumably due to Schiff's base formation; no such colour was seen with secondary (for example, proline, N-methylglycine) or tertiary (N,N-dimethylglycine) amines. The chromatogram is now heated at 90° for 10 min. to effect transamination. Both it and the control chromatogram are now sprayed with 0·25 per cent ninhydrin in acetone, and allowed to stand at room temperature or heated for 5 min. at 90°. The changes in colour observed under these conditions are summarized in Table 1.

Table 1. Colours obtained with Representative Amines on Ninhydrin-treatment Before and After Treatment with Pyridoxal

Compound*	Colour formed		
	Without pyridoxal 5 min., 90° C.	With pyridoxal 5 min., 24° C.	With pyridoxal 5 min., 90° C.
Pyridoxamine	orange	orange	orange
α-Amino-acids and their peptides†	purple or blue-purple	orange	orange-purple
α-Substituted α-amino-acids‡	purple	orange	orange-purple
β-Amino-acids and their peptides§	purple	light yellow	purple or purple-brown
γ-Aminobutyric acid	light purple	light yellow	purple
Agmatine, ethylamine, histamine, putrescine, taurine, tryptamine and tyramine	purple or purple-grey	yellow	purple or grey
Benzylamine	purple	light yellow	orange-blue
Serine-3-phosphate and threonine-3-phosphate	purple	purple	purple

* 5 μl. of an *M*/50 solution of the test compounds were used. This is much higher than the sensitivity of the method requires.

† Amino-acids: Alanine, α-aminobutyric acid, α-alanine ethylester, aspartic acid, asparagine, arginine, citrulline, cysteic acid, cystine, diaminopimelic acid, glutamic acid, glycine, histidine, homoserine, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine, phenylglycine, serine, threonine, tryptophan, tyrosine, valine. Peptides: Alanylglycylglycine, glycylalanine, alanylglycine, glycylasparagine, leucylglycine.

‡ α-Aminoisobutyric acid, α-methylserine, α-methylolserine.

§ β-Alanine, β-aminobutyric acid, β-alanylglycine, β-alanylleucine, β-alanylhistidine.

It is evident that the sequential treatment with pyridoxal and ninhydrin provides a convenient means for distinguishing α-amino-acids (or their peptides) from β-amino-acids and other primary amines. The former transaminate with pyridoxal to yield pyridoxamine and an orange colour with ninhydrin; the latter with the one exception noted (benzylamine) do not transaminate at 90° to an extent sufficient to alter materially the colour obtained with ninhydrin. Many of the α-amino-acids develop no colour with ninhydrin within 5 min. at room temperature whereas pyridoxamine does; consequently the colour reactions exhibited by α-amino-acids on the pyridoxal-treated chromatogram under these conditions are not complicated by development of the purplish tint due to residual amino-acid that appears on heating. On the other hand, pyridoxal inhibits the rate of colour development of amines with ninhydrin, presumably because of formation of the Schiff's bases, and it is necessary to heat to obtain colour development with these compounds. It is interesting to note that α-amino-acids which lack an α-hydrogen atom (for example, α-methylalanine) and hence cannot transaminate by the mechanism postulated for unsubstituted α-amino-acids[3] nevertheless give an orange spot indicative of pyridoxamine formation. Separate investigation has shown that decarboxylation accompanied by partial transamination occurs in these instances[5]; the reaction provides a model for the enzymatic decarboxylation of amino-acids by pyridoxal phosphate proteins. Although appropriate metal ions catalyse transamination reactions of this type in aqueous solutions[2,3], their addition is not required for, and does not alter the course of, the reaction on paper under the conditions used here. Relatively little or no formation of pyridoxamine occurs with serine-3-phosphate and threonine-3-phosphate. This is to be expected since α,β-elimination reactions to yield nitrogen-free products predominate with these amino-acids, as reported elsewhere[6]. The reactions of the amino-acids with pyridoxal on paper correspond closely to those previously observed between amino-acids and keto-acids under similar conditions[7,8].

The procedure outlined here permits further refinements. By reducing the pyridoxal concentration, or by incorporating this reagent into the ninhydrin spray, it should be possible to obtain colours varying from bluish-purple to orange with the various α-amino-acids, depending upon the ease with which they undergo transamination. Examination under ultra-violet light of the pyridoxal-treated chromatogram, before ninhydrin treatment, reveals distinct differences in the fluorescent characteristics of certain of the Schiff's bases obtained. Finally, the method in reverse (pyridoxamine spray followed by ultra-violet examination or ninhydrin-treatment) can provide a means for detection of α-keto-acids on papergrams. In this application, however, the procedure has proved less sensitive than chromatography of the keto-acid 2,4-dinitrophenylhydrazones.

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[1] Crumpler, H. R., and Dent, C. E., *Nature*, **164**, 441 (1949).
[2] Metzler, D. E., and Snell, E. E., *J. Amer. Chem. Soc.*, **74**, 979 (1952).
[3] Metzler, D. E., Ikawa, M., and Snell, E. E., *J. Amer. Chem. Soc.*, **76**, 648 (1954).
[4] Snell, E. E., *J. Amer. Chem. Soc.*, **67**, 194 (1945).
[5] Kalyankar, G. D., and Snell, E. E. (to be published).
[6] Longenecker, J. B., and Snell, E. E., *J. Biol. Chem.*, **225**, 409 (1957).
[7] Giri, K. V., and Kalyankar, G. D., *Naturwiss.*, **40**, 224 (1953).
[8] Giri, K. V., Kalyankar, G. D., and Vaidyanathan, C. S., *Naturwiss.*, **41**, 14 (1954); *J. Ind. Inst. Sci.*, **37**, 304 (1955).

Non-specific Hydroxylation of Aromatic Amino-Acids by an Insect Cuticle

During an examination of the amino-acid composition of the larval cuticle of the blow-fly, *Calliphora vomitoria*, it was found that phenylalanine and tyrosine were readily removed by extraction with water at 50° C. for 2 hr. Surprisingly, however, these amino-acids could not be recognized in the extract.

Instead, alanine and ninhydrin-negative diphenolic compounds were found. This observation suggested that the cuticle is capable of hydroxylating aromatic amino-acids in a manner similar to the action of the artificial system studied by Dalgliesh[1].

To explore this possibility further, larval cuticles in batches of twenty were cleaned by scraping, extracted in water, and then incubated in 0·1 per cent phenylalanine solution. After 24 hr. the solution was made slightly acid with sulphuric acid and extracted with peroxide-free ether. The ether was removed by evaporation, and the solid residue taken up in 10 per cent *iso*-propyl alcohol and examined chromatographically. Butanol–acetic acid–water (4 : 1 : 5), *m*-cresol–acetic acid–water (50 : 2 : 48), and benzene–acetic acid–water (2 : 2 : 1) were used as solvents. The chromatograms showed ninhydrin-negative silver-reducing spots indistinguishable from those produced by hydroquinone and catechol, and their identity was further established by the fact that they gave the same reactions as these compounds when tested with the following reagents: Ehrlich's reagent, ferric chloride, Roux's sucrose reagent, Pauly's reagent, and Folin and Ciocalteu's reagent.

Similar results were obtained when cuticles were incubated with tyrosine, and the cuticles were also found to be capable of forming hydroxylated products when tryptophan was used as substrate.

These observations indicate the possibility that larval cuticles may contain hydroquinone and catechol. Five hundred cuticles were therefore cleaned and extracted with hot absolute ethanol for six hours, and the extract concentrated and examined chromatographically. In accordance with expectations hydroquinone and catechol were shown to be present.

The presence of deaminated dihydroxyphenols in the larval cuticle must clearly be taken into account in studying the process of puparium formation, and in the full account of these observations which is being prepared evidence will be submitted showing that hydroquinone plays a predominant part in the tanning process by which the larval cuticle is hardened.

R. Dennell

Department of Zoology,
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Manchester 13.
June 7.

[1] Dalgliesh, C. E., *Arch. Biochem. Biophys.*, **58**, 214 (1955).

Identification of Edible Oils and the Detection of Oil Adulteration by Differential Infra-red Spectroscopy

A recurring problem in the food enforcement field is detecting the adulteration of butter and olive oil with other fats and oils. Many methods of detection have been devised, but most of them lack either sensitivity or speed.

Infra-red spectroscopy has been widely used for the detection and identification of organic materials but has not been used for the identification of oils or fats, because their spectra are similar. However, applying differential spectroscopy[1], minor differences

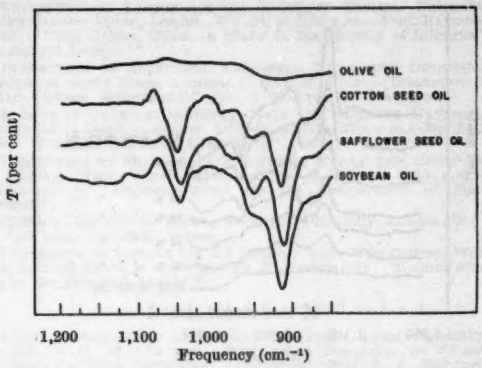

Fig. 1. Differential spectra of olive, cotton seed, safflower seed, and soybean oils with olive oil as reference

in the spectra of fats and oils are accentuated, permitting the detection of one oil in the presence of another. Other applications of infra-red spectroscopy to the field of fats and oils are reviewed by O'Connor[2,3].

The apparatus used for this investigation was a Perkin–Elmer Model 21 double-beam infra-red spectrometer which measures the differences in absorbance between two light beams. The instrument was equipped with sodium chloride cells of 1 mm. path-length, and was operated with a fixed slit of 300 microns at a speed of 100 cm.$^{-1}$/min. over the region 1,200–900 cm.$^{-1}$.

A solution containing 10 per cent w/v of pure olive oil in carbon tetrachloride is placed in both the reference and sample cells. With the cells in place, the instrument is adjusted to read approximately 75 per cent transmission at 900 cm.$^{-1}$ with the beam trimmer. (The pen is set at this point on the chart so that deviations may be indicated from this value in either direction.) The spectrum is then recorded over the range 1,200–900 cm.$^{-1}$. Under these conditions the pen-trace obtained is essentially a straight line since there is no difference between the spectral absorption in the two beams. The sample cell is then filled with a 10 per cent w/v solution of the oil under examination while leaving the pure olive oil solution in the reference beam. The spectrum is recorded over the same range using the same

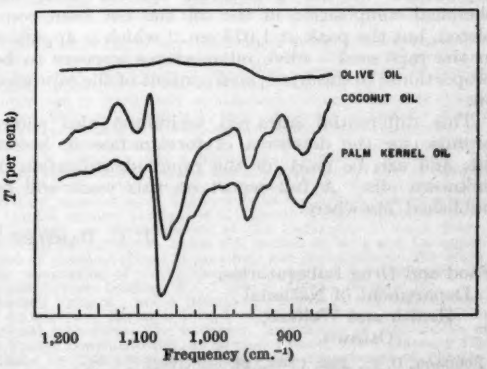

Fig. 2. Differential spectra of olive, coconut and palm kernel oils with olive oil as reference

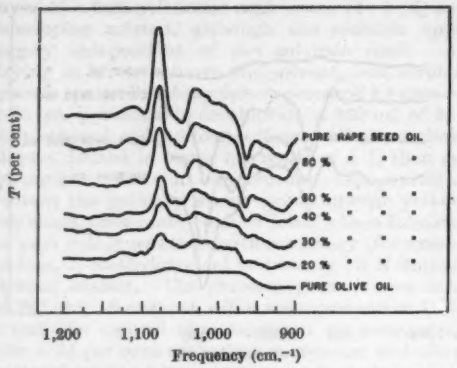

Fig. 3. Differential spectra of olive and rape seed oils and their mixtures with olive oil as reference

chart paper. Differences in the spectra of the two oils, which are not apparent by normal recording, are clearly indicated by deviations above and below the reference spectrum. These deviations are characteristic of the type of oil, and in some cases may be used for identification purposes.

Fig. 1 shows the differential spectra of olive, cotton seed, safflower seed and soybean oils relative to olive oil in the reference beam. Similarly, Fig. 2 shows the differential spectra of olive, coconut and palm kernel oils against olive oil. In both figures the percentage transmission scale has been displaced for each spectrum in order to permit the presentation of several spectra in the same figure.

The differential spectral procedure was also applied to mixtures of oils. Fig. 3 shows the differential spectra for mixtures of olive and rape seed oils relative to olive oil. As little as 20 per cent of rape seed oil may easily be detected in olive oil by this method. A similar sensitivity has been attained for the detection of several other oil mixtures.

Using this procedure, more than two hundred samples of olive oil have been examined for adulteration. Rape seed oil was detected in several samples, and its presence confirmed by isolation and characterization of the erucic acid. All olive oil samples found to be pure by the infra-red procedure were shown to be free of adulteration by all other methods tried.

The correlation between the various peaks and depressions in the differential spectra with the chemical composition of the oil has not been completed, but the peak at 1,078 cm.$^{-1}$ which is apparent in the rape seed – olive oil mixtures appears to be proportional to the erucic acid content of the rape seed oil.

This differential infra-red technique also shows promise for the detection of foreign fats in butter fat, and can be used for the rapid identification of unknown oils. A full report on this work will be published elsewhere.

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Influence of Ion Exchange on Size and Shape of Chain-like Polyelectrolyte Molecules

On conversion of the sodium salt of alginic acid (poly-*d*-manuronic acid) into the magnesium salt, a marked alteration of molecular weight and viscosity properties takes place, as shown by the figures in Table 1. The molecular weights were determined by light scattering and refractivity measurements (λ = 536 and 446 mμ, angular scattering dependence, in some tests, between 135 and 25°, 19 angles), and the viscosities were measured in Flory and Couette viscometers, the rate of shear being varied from 0·4 to 2,500 sec.$^{-1}$. In most experiments the solvent was an unbuffered aqueous solution of, respectively, 0·100 *M* sodium chloride and 0·0200 *M* magnesium chloride, *p*H about 5, but some of the viscosity tests were also made in solutions of different ionic strength and in the presence of sodium or magnesium veronal buffers, *p*H = 7·43.

Table 1

	Weight average molecular weight × 10^{-3} (26 ± 2°)	Intrinsic viscosity 100 cm.^{3} sol./gm. (25·0°)	Influence of rate of shear on viscosity at low ionic strength
Sodium alginate	110 ± 20	9·34 ± 0·09	Relatively large
Magnesium alginate (I)	1,250 ± 300	6·86 ± 0·07	Small
Magnesium alginate (II)	350 ± 100	7·80 ± 0·10	

Magnesium alginate (I) was prepared from a non-oriented sodium alginate gel by treatment with 2 *M* magnesium acetate, the alginate concentration being 0·5 gm.-equiv./l. reaction mixture. Magnesium alginate (II) was obtained by dialysing solutions of the same sodium alginate, 0·015–0·05 gm.-equiv./l., against 0·02 *M* magnesium chloride. On reconversion of (I) into sodium alginate a material of average molecular weight (96 ± 8) × 10^3 was obtained.

The results indicate that the bivalent magnesium ions combine with carboxylate groups of the alginate to form inter- and intra-molecular salt bridges, while the monovalent sodium ions are not capable of producing such links. The relative number of inter- and intra-molecular bridges must depend on: (*a*) the degree of orientation of the alginate chains at the moment of the sodium magnesium ion exchange; (*b*) the concentration conditions. In the magnesium alginates (I) and (II), both inter- and intra-molecular bonds appear to play a part: the former are made responsible for the large molecular weights, while the latter bring about a more compact configuration, which in turn gives rise to relatively small intrinsic viscosities and rate of shear dependence.

A detailed description of these experiments and molecular dimensions will be given elsewhere.

We are grateful to Prof. J. A. V. Butler who made it possible for us to use the Couette viscometer at the Chester Beatty Research Institute.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 18

BRITISH OCCUPATIONAL HYGIENE SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. T. F. Hatch (University of Pittsburgh): "Human Engineering".

BRITISH COMPUTER SOCIETY (at the L.C.C. County Hall, London, S.E.1), at 6.15 p.m.—Mr. A. J. Barnard: "Applications of a Computer to the work of Norwich Corporation and Plans for Future Use".

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. V. F. Henley: "Production of Multi-Coloured Designs of Anodised Aluminium".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at Erith Grammar School, Avenue Road, Erith), at 7 p.m.—"Careers in Chemistry".

Tuesday, November 19

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "Evolution Observed".*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT and UTILIZATION SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Measurement of Dynamic Characteristics of Electrical Machines", opened by Mr. J. M. Layton, Mr. V. N. Manohar and Mr. R. A. Stevens.

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Dr. P. L. Clegg: "The Flow Properties of Polythene and their Effect on Fabrication".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Science and Furniture". Chairman: Sir Gordon Russell, C.B.E., M.C. Speakers: Mr. J. C. Pritchard, O.B.E., Dr. W. F. Floyd and Monsieur René Varin, C.B.E.

BRITISH GLACIOLOGICAL SOCIETY (joint meeting with the HERBERTSON SOCIETY, at the School of Geography, The University, Mansfield Road, Oxford), at 8.15 p.m.—Mr. J. A. Heap: "Glaciology in the Modern World".

Wednesday, November 20

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. M. E. L. Mallowan: "Excavations at Nimrud, 1957".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Mr. H. Riehl and Mr. D. Fultz: "Jet Streams and Long Waves in a Steady Rotating-Dishpan Experiment—Structure of the Circulation"; Mr. G. H. Tucker: "Evidence of a Mean Meridional Circulation in the Atmosphere from Surface Wind Observations".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Sir Harry Campion, C.B., C.B.E.: "Recent Developments in Economic Statistics" (Presidential Address).

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "Problem Families". Speakers: Mr. Paul Cadbury, C.B.E., Mr. M. MacGregor, and Miss Catherine Wright.*

ROYAL INSTITUTE OF CHEMISTRY (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 6.30 p.m.—Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. W. F. Higgins: "Protection of Magnesium Alloys".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. F. A. Champion: "The Painting of Aluminium and its Alloys".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 7.45 p.m.—Concert of Music and Folk Dances of India.*

Thursday, November 21

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Symposium on "Water Pollution" opened by Dr. Hynes, Dr. Butcher, Mr. Pentelow, Mr. Westlake, Mr. Pettett and Major J. I. Spicer.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Eric Rideal, F.R.S., and Mr. F. H. Taylor: "On Hæmolysis and Hæmolytic Acceleration"; Mr. D. A. T. Dick and Miss Leah M. Lowenstein: "Osmotic Equilibria in Human Erythrocytes Studied by Immersion Refractometry".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. C. K. Haswell: "The Development of Power in the Service of Man".*

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. H. Humphrey: "Antibody Metabolism".* (Eleventh of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 26, 28 and December 3 and 5.)

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Raymond Irwin: "The Golden Chain—a Study in the History of Libraries". (Inaugural Lecture.)*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "High-Voltage Experiments" opened by Prof. E. Bradshaw.

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. B. J. Gee: "Producer-Gas Fired Lime Kilns".

INSTITUTION OF MECHANICAL ENGINEERS, HYDRAULICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Instrumentation for the Measurement of Fluid Pressure".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Swanley Hall, Wye College, Wye, near Ashford, Kent), at 8.15 p.m.—Mr. M. Westmacott: "Mountaineering in the Peruvian Andes".*

Friday, November 22

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Fossil Evidence for Wind Directions". Chairman: Prof. P. A. Sheppard. Speakers: Mr. R. A. Bagnold, Mr. N. D. Opdyke, Prof. S. K. Runcorn and Prof. F. W. Shotton.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. W. H. McCrea, F.R.S.: "Physics and the Astronomical Universe".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (preferably with a special interest in inorganic chemistry) IN CHEMISTRY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (November 23).

LECTURER (with special qualifications in physical chemistry); and an ASSISTANT LECTURER (Grade B, with special qualifications in inorganic or organic chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 25).

RESEARCH ASSISTANT (graduate suitably qualified for registration for the Ph.D. (Internal, London) degree) IN THE DEPARTMENT OF CHEMISTRY—The Head of the Department of Chemistry, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 25).

RESEARCH FELLOW IN THE RESEARCH DEPARTMENT of the Institute of Education; the field of investigation will be "Science and Education"—Prof. E. A. Peel, The University, Edmund Street, Birmingham (November 25).

JUNIOR RESEARCH FELLOW IN SOIL SCIENCE, to carry out investigations of problems relating to soil structure—The Secretary, The University, Aberdeen (November 27).

ASSISTANT LECTURER OR LECTURER IN VETERINARY PREVENTIVE MEDICINE—The Registrar, The University, Liverpool (November 30).

UNIVERSITY LECTURER (preferably with qualifications in applied thermodynamics) IN MECHANICAL ENGINEERING—The Secretary, The University, Aberdeen (November 30).

READER IN MATHEMATICAL STATISTICS in the Research School of Social Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 2).

LECTURER or ASSISTANT LECTURER (graduate in metallurgy or pure science, and preferably with experience in production metallurgy) IN METALLURGY—The Registrar, The University, Leeds 2 (December 9).

UNIVERSITY LECTURER IN STATISTICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, Arts School, Bene't Street, Cambridge (December 11).

LECTURER IN PSYCHOLOGY at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 13).

SENIOR LECTURER IN THE DEPARTMENT OF GEOPHYSICS, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 15).

LECTURER IN PATHOLOGY at Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 19).

SENIOR RESEARCH FELLOW; RESEARCH FELLOW; JUNIOR RESEARCH FELLOW; and a RESEARCH ELECTRONICS ENGINEER on the staff of the Nuclear Physics Research Unit, Department of Physics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 31).

LECTURER IN MICROBIOLOGY at the University of Cape Town, South Africa, for duties which will include lectures and the supervision of practical classes in mycology and protozoology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 15).

SENIOR FELLOW; and a RESEARCH FELLOW IN THE DEPARTMENT OF GEOPHYSICS, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, W.C.1 (January 17).

CHAIR OF THEORETICAL PHYSICS in the Department of Physics, University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 31).

DEMONSTRATOR IN THE DEPARTMENT OF GEOLOGY—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (January 31).

LECTURER IN PHYSICS at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 31).

SENIOR LECTURER or LECTURER IN ANIMAL HUSBANDRY in the Faculty of Agriculture, Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 14).

ABSTRACTOR (with a degree in agriculture or natural science and a knowledge of languages)—The Director, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire.

ASSISTANT LECTURER, Grade B (with an honours degree or equivalent and preferably with teaching and industrial or research experience), IN CHEMISTRY—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

ASSISTANT PROFESSOR (preferably with a good background in analytical, inorganic or physical chemistry) IN GENERAL CHEMISTRY—Lester Kieft, Department of Chemistry, Bucknell University, Lewisburg, Pa., U.S.A.

CHAIR OF MATHEMATICS, tenable at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1.

JEYES' RESEARCH FELLOWS (2) (suitably qualified graduates) IN THE BIOLOGY DEPARTMENT, for research on (*a*) biological, and (*b*) physico/chemical aspects of chemical soil sterilization—The Registrar, University College of North Staffordshire, Keele, Staffs.

LECTURER (preferably with a higher degree and research interests) IN INORGANIC CHEMISTRY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree in physics and preferably experience in nuclear radiation measurement), to work in a Section concerned with a wide range of measurements of nuclear and allied radiations—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1613/34.

SENIOR LECTURER (man), to be responsible for science students training to teach mainly chemistry and physics in Technical Colleges—The Director, Training College for Technical Teachers, Queen Street South, Huddersfield.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1956–57. Aden Protectorate. Pp. 16. 9*d*. West Indies. Pp. 15. 9*d*. Survey and Summaries of Reports. Pp. 16. 9*d*. (London: Empire Cotton Growing Corporation, 1957.) [179

Proceedings of the Royal Irish Academy. Vol. 58, Section B, No. 8: The Stratigraphy and Structure of the Country around Sneem, Co. Kerry. By J. G. Capewell. Pp. 167–184+plate 18. 2*s*. Vol. 58, Section B, No. 9: Quaternary Deposits around Lough Foyle, North Ireland. By Nora F. McMillan. Pp. 185–206. 2*s*. Vol. 58, Section B, No. 10: The Variations of Terminal Voltage and Electrode Potentials with Current Density During Chloride Electrolysis. By V. de Valera. Pp. 207–236+plates 19 and 20. 5*s*. 6*d*. Vol. 58, Section B, No. 11: The Chemical Composition of some Western Irish Fresh Waters. By E. Gorham. Pp. 237–244. 1*s*. (Dublin: Hodges, Figgis and Co., Ltd., 1957.) [179

Collective Index of the *Journal of the Institute of Brewing*, 1946–1955. Pp. iv+218. (London: Institute of Brewing, 1957.) 105*s*. [179

British Electrical and Allied Industries Research Association. Technical Report L/T352: Short-Time Electrical Breakdown of Solids by External Discharges. By Dr. K. W. Ogilvie. Pp. 11+13 figures. 12*s*. 6*d*. Technical Report W/T32: The Influence of Ultrasonic Waves on Biological Materials. By Dr. Margaret J. Thornley. Pp. 35+3 figures. 21*s*. (Leatherhead: British Electrical and Allied Industries Research Association, 1955 and 1956.) [179

Journal of Mental Deficiency Research. Vol. 1, No. 1 (July, 1957). Pp. 65. Published half-yearly. Annual subscription rate: 15*s*. Single Issues: 7*s*. 6*d*., or 1.50 dollars. (Sevenoaks: Mr. A. Highfield, Publishing Manager, 10, Shendon Way, 1957.) [179

Forestry Commission. Seventh British Commonwealth Forestry Conference, 1957 (Australia and New Zealand). Experiments on the Control of the Pine Weevil, *Hylobius abietis* L. By Dr. Myles Crooke. Pp. 37. Improvement of Scots Pine in Britain by Selection and Breeding. By J. D. Matthews and C. McLean. Pp. 14. Is Present Day Forest Products Research Meeting the Needs of the Forester? By O. J. Sangar. Pp. 7. Planned Land Use and the Classification and Dedication of Land for Forestry. By Sir Henry Beresford-Peirse. Pp. 6. Planning a Forestry Research Programme. By M. V. Laurie. Pp. 7. The Effect of Rate of Growth (Ring Width) on the Density of Soft Woods. By B. J. Rendle and E. W. J. Phillips. Pp. 6. Top Dying of Norway Spruce in Great Britain. By T. R. Pearce. Pp. 9. The Desirable Balance between Hardwood and Softwood Production in Great Britain. By H. M. Steven and W. M. McNeill. Pp. 10. Developments in Pulping and Board Manufacture in Great Britain. By A. Watt. Pp. 5. (London: Forestry Commission, 1957.) [189

International Council of Scientific Unions. Financial Statement, 1955–1956. Pp. 8. (London: International Council of Scientific Unions, 1957.) [189

Forestry Commission. Forest Record No. 32: New Ways of Using the General Tariff Tables for Conifers. By H. D. S. Finch. Pp. 11. 1*s*. 3*d*. net. Leaflet No. 5 (revised 1957): *Fomes annosus*: a Fungus causing Butt Rot and Death of Conifers. Pp. 10. 8*d*. net. Bulletin No. 30: Exotic Forest Trees in Great Britain: Paper prepared for the Seventh British Commonwealth Forestry Conference, Australia and New Zealand, 1957. Edited by James Macdonald, R. F. Wood, M. V. Edwards, and J. R. Aldhous. Pp. vii+167. 17*s*. 6*d*. net. (London: H.M. Stationery Office, 1957.) [189

Regional Council for Further Education for the South West. Bulletin of Special Courses in Higher Technology, 1957–58. Pp. 32. (Bristol: Regional Council for Further Education for the South West, 1957.) 2*s*. [189

Oil Pollution of Sea and River Birds. By R. C. G. Hancock. Pp. 8. (London: Royal Society for the Prevention of Cruelty to Animals, 1957.) 6*d*. [189

Other Countries

Tanganyika Geological Survey. Annual Report of the Geological Survey Department for the year ending 31st December, 1956. Pp. iv+20. Geological Survey Map No. 921. (Dodoma: Department of Geological Survey, 1957.) [179

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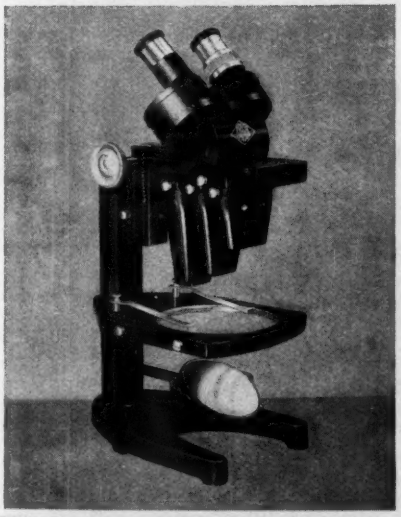

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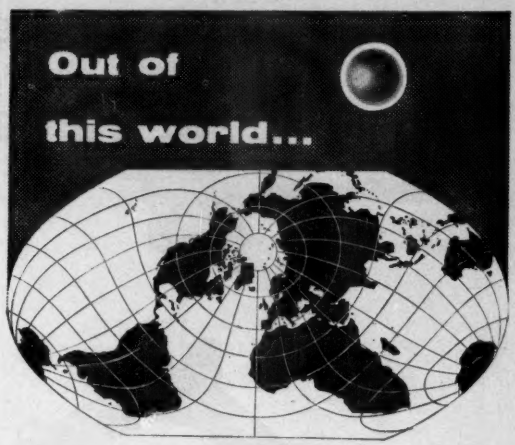

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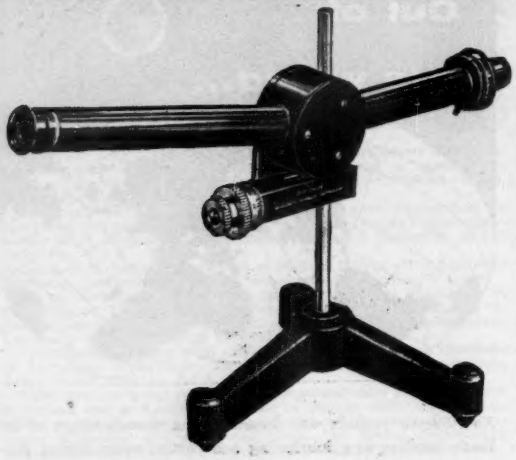

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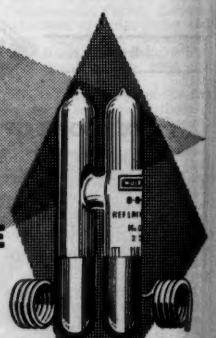

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